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Chicago: DWIGHT H. EARLY
100 North LaSalle St.
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EDITORIAL

Runt Pig and Wall Writing

AGRICULTURE is the runt pig in the man power litter," says Secretary of Agriculture Claude R. Wickard in a newscast quotation just heard. He was further quoted to the effect that farmers and their families must simply buckle down a little harder, keep on working from sunup to sundown, and despite all handicaps achieve the higher quotas set for them in 1943, notably in dairy, livestock, poultry, and certain fruit and vegetable products.

Beside those brave words comes the memory of some weary words, spoken months ago in a farm kitchen after late evening chores were done. Talk had touched on sundry things affecting the war effort, to which this farmer and his family were deeply dedicated. They had carried the ball in war bond sales, and buying. They had turned thumbs down on every gift and gadget made of metal. They had the grief of a favorite nephew killed at Pearl Harbor.

Whether labor was more a sinner or more sinned against; an almost axiomatic belief that big business was sinning against everybody; the irony of man power removed from the farm, yet remaining in non-essential occupations; the travesty of metals denied for farm machines, yet allowed for all manner of civilian goods; wages and prices tied to a kite and agriculture not allowed to grab at the tail—all these had been mentioned by one or another. And then, rather irrelevantly it seemed at the time, the farmer remarked:

"I have seen the handwriting on the wall. I am getting rid of all the work I can. I will use hired help if I can get it, but for myself I intend to work 48 hours a week, yearround average. You know how far that will go on 215 acres."

Is this farmer *sui generis,* or are these same thoughts taking shape beside a million or five million kitchen stoves? Will thoughts so close to earth give ground to words by Wickard, so far away? If this man or this million be wrong, who is there among us to cast the first stone? What can we do about it?

As agricultural engineers we can help him, all five million of him, to get rid of all the work he can, and at the same time make his hours go farther on his acres. In so doing we shall fortify the American way of life in agriculture and the way of freedom in all the earth.

On Being a Guinea Pig

AS WE understand it, the guinea pig symbolizes any sacrifice on the altar of experiment. As such, its chance of survival is small. Hence we have felt no complacence about the campaign, now apparently successful, to use as a guinea pig the food-producing machinery industry.

We could resign ourselves to experimental sacrifice of the industry which makes chewing gum, neckties, smoking tobacco, greeting cards, or juke-box records. For some of these we have a weakness, but no such weakness as would attend an absence of bread and butter. If there must be encroachment on food, let it be at bakery and creamery, not at point of creation. We could live and be strong on raw wheat and raw milk.

Critical attention should be given to the policy of concentration, and particularly its pattern. Apparently this is an attempt to borrow bodily from British experience, without due regard for the differences between that country's farm machinery industry and our own.

It was remarked recently that the only "secret weapon" which we have and others have not is the production line. So far as we know, America is the only nation which has attained mass production in farm machines. Being not readily convertible to munitions manufacture, much of the special tooling for mass production of farm machines will stand idle unless used, where and as installed, for continued production of those same machines.

In a country where such mass manufacture has not been attained, a concentration of production in smaller plants might well be feasible and efficient. It might not, and probably will not, be similarly practicable and efficient in this country. It should not be attempted unless analyzed and approved by men who know what it is all about.

We should weigh the effect of concentration on the ability of farm machinery dealers to stay in business and render service. To disrupt the one agency which knows how to time a binder or a baler, to splice a hay rope and set the suck of a share, would be a national disaster. With the food problems we face, this is no time for amateur operations on the guinea pig.

Let's Be Sensible

AN A.S.A.E. member who owns a farm and directs its operation recently brought to our attention the form he was required to fill out in order to apply for permission to buy a tire needed on his farm truck. With 1200 acres divided between crop land and rough pasture, devoted to production of beef and pork, much of the acreage remote from the farmstead and all at considerable distance from a shipping point, his need for uninterrupted truck service is obvious.

The apparent purpose of the form was to intimidate him by asking for a host of figures he could not accurately supply, leading up to a boldface warning that any misstatement was punishable by ten years in prison and $10,000 fine. A farmer who kept all the detailed records necessary to answer the questions would have had little time left for farming. One question that we recall demanded the "average number of miles run on tires removed in 1941." He had not removed any tires in 1941.

Accompanying the application form was a 32-page bulletin supposed to make clear the meaning of the questions and explain the necessary calculations. The form was to be filed, not with a local rationing board, but with some agency in Detroit, Michigan. If and when that office granted the petition, he could buy a tire. Meanwhile, if the well went dry and it was necessary to haul water, heaven help the hogs.

Farmers are patient and patriotic people. They will put up with a lot of annoyance and bear a lot of sacrifice, as long as it makes sense. But there is at least one farmer who is wondering whether the bureaucrats who boss the war effort are as ignorant of its other phases as they are of farm truck usage. For morale as well as for efficiency, such time-killing deviations from common sense should be abolished now and avoided in future.

AGRICULTURAL ENGINEERING

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A Program for Postwar Farm Building

By Ray Crow

MEMBER A.S.A.E.

THE federal census report for 1940 gives the estimated value for farm buildings in the nation as being $1.1 billion less in 1939 than for 1919 and nearly $2 billion less than for 1929. These figures are not conclusive because of the variation of the commodity value of the dollar from time to time, and furthermore they do not take into account the value of these buildings from an efficiency standpoint. That is, due to changes in methods and types of farming, structures may have considerable intrinsic value and yet be practically worthless to the present farm operation.

However, this gives at least partial confirmation to statements made frequently by various authorities during recent years, that not only has the condition of existing farm structures deteriorated seriously but also that new construction and modernization have utterly failed to keep pace with even essential needs. Since construction work is now practically frozen for the duration, the relative condition of farm structures at the end of the war will be worse than in 1940.

Most of us at all familiar with the situation had agreed since long before the war began that a large-scale farm building construction program would essentially further the progress and prosperity of agriculture, which in turn would contribute immeasurably to the stabilization of our national economy. However important such a program would have been in the past, its successful prosecution during the immediate postwar period will be doubly so as a postwar economic measure. In addition to bringing the agricultural farm plants up to modern standards, thus adding to the efficiency and scope of farm operations, improving the farmer's standard of living and increasing his net income and therefore his purchasing power, it also will absorb into constructive peacetime efforts a considerable part of the labor and material now going into war work. This may aid materially in preventing, or at least ameliorating, that postwar depression which so many authorities anticipate.

Present indications are that at the close of the war farmers will be better able to finance such a program than at any time in the recent past. This will be due to higher prices paid for farm products plus the fact that fewer things are available for them to buy. Furthermore, so far there is little or no prospect of a repetition of that unwarranted inflation in farm land values which so seriously disrupted agricultural economy after World War I.

On this basis considerable farm building construction will be started and carried out as soon after the war closes as materials again become available. However, if in this work the farmer is left entirely to his own initiative, plus only the individual assistance of a few technicians scattered over the country as has been the normal procedure, this construction both in volume and quality will fall far short of that which otherwise it might attain. The technical and business training of the average farmer is not sufficient to enable him to handle such a program with the coordinated efficiency demanded by modern standards.

It is here that agricultural engineers and their associates, both individually and collectively through the various federal or state agencies and other organizations, should come into the picture. Theirs is both the opportunity and responsibility, not only to guide the efforts of the farmers themselves along proper lines but also to coordinate into the program the much needed and readily available assistance of many other interested individuals and groups, who next to the farmers themselves would profit materially from the carrying out of any such program. My contacts and connections with industrial, commerical, and civic organizations, business men, and farmers themselves indicate that all these groups are now acutely aware of the fact that the prosperity of the one is inseparably linked with that of the other. On this basis I submit that if a detailed workable plan of coordinated action is presented, which gives an equitable division of the work, responsibility, and benefits involved, each group will willingly do its assigned share.

The first requisite of any such plan will be an authentic, reliable tabulation of the scope, distribution, and amount of this potential construction as a basis on which to formulate and prepare to carry out the actual construc-

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tion operations in an efficient way. Are we talking in terms of millions, billions, or tens of billions of dollars? No one claims to know. Guesses have been made from time to time by various interested organizations, but none of these pretend to be sufficiently accurate to use as definite bases for actual commitments. The federal farm housing survey made in 1934 by the Civil Works Administration, but directed by the Bureau of Home Economics, apparently was conducted with this purpose in view, but it takes into account only the dwellings, probably less than half of the entire problem.

Then again what is available locally in the way of cash, credit, labor, and materials that can be applied to such building construction work and to what extent can these things be relied on as definite contributions to the program? Is the collective farmer as much interested in securing better structures as some of us think he is? Will loan and credit agencies cooperate in such a program in a way that all concerned can use these services advantageously? To answer these and other similar questions will require a reasonably careful survey and tabulation of results thereof which will take into account a number of factors including the following:

1 Determine number, type, size, and general condition of existing farm structures as at the close of the war, together with an estimate of the potential volume of building construction work necessary during the immediate five-to-ten-year postwar period to repair, reconstruct, and modernize these structures until they will conform to efficient standards of modern farm practice.

2 In addition to the foregoing, forecast the number, type, and size of new and additional farm structures that should be erected during that same period to establish the operation of farm plants on an efficient basis, taking into account probable changes and revisions in the methods and types of farming.

3 Determine approximately the amount of local labor and materials over and above the operating farm needs that can be made available in the prosecution of such a building program.

4 Determine the attitude of the farm owners themselves toward cooperation in such a program, particularly whether landlords will be interested in improving the condition of farm plants for their tenants, on the basis that such improvements would be a profitable investment by increasing the efficiency of their farm operations.

HOW ONE ALABAMA COUNTY CARRIED OUT A SURVEY OF FARM BUILDING CONDITIONS AND NEEDS

But, you say, how can such a survey be accomplished in any reasonable length of time and without a vast expenditure of money? Let me tell you how it was done in one Alabama county in 1934. The chambers of commerce in the two larger towns of the county, at the instigation of and with the assistance of the county home demonstration agent, the county agricultural agent, the CWA county director, and one or two other public-spirited citizens, not only sponsored and carried out a survey of the condition of farm structures of that county, but also formulated a countywide plan for improving that condition. The plan was developed into a CWA project and submitted through the regular channels for approval. Unfortunately its operation as a federal project was prohibited by the requirement that federal funds in those operations must be expended on public property or in the public interest. However, the apparent merits of the plan created a great deal of favorable comment from important governmental officials.

The survey itself was carried out somewhat as follows: The individuals mentioned acting as a committee drew up a questionnaire based on the one used in the federal farm housing survey but modified to suit local conditions. Copies of this questionnaire were placed in the hands of businessmen throughout the county and the purpose of the survey explained to them, along with instructions as to how it should be used to obtain reasonably uniform results. As individual owner-operating farmers came into the places of business, they were interviewed by the businessmen who assisted them in filling out the questionnaire. A special questionnaire was developed to suit the conditions of landlord ownership and where necessary landlords were interviewed through personal calls. However, many of these interviewers were also landlords and filled out their own questionnaires.

THE SURVEY WAS COMPLETED IN THREE MONTHS AT SMALL COST AND WITH BIG RESULTS

As the filled-out questionnaires were collected and tabulated, the location of each surveyed farm was marked on a county map. A few personal visits were then made by volunteer workers to round out certain areas that seemed to be inadequately represented, after which the complete tabulation of the potential scope and value of the proposed construction work was made. Local carpenters and builders were pressed into service to check the individual questionnaires as to the amount of materials and labor that would be required to do the work as outlined. To some extent the estimate was examined in the light of the known resources of the farmer and in many cases it was modified, generally downward, if it seemed out of line with the farmer's ability to pay.

When finally completed the tabulation was broken down into a rough approximation of actual items of material and labor that would be required to accomplish the desired results. Against this a check of the available labor for the purposes as indicated in the questionnaire was made to determine to what extent, if any, labor from other sources would need to be imported. It was found that common labor in more than the required quantity needed was available but that probably a shortage of certain skilled labor would develop. The cost of the materials was estimated by the dealers in these various items and, as indicated above, all of this became the basis for developing a CWA project.

In this particular county there were found to be approximately 3,500 farms, of which 1,200 were owner-operated. The 2,300 tenants were divided almost equally between renters, who paid either cash or a share of the crop for the use of the land and buildings but who owned their own livestock and farming equipment, and the so-called sharecroppers where the landlords furnished all equipment and the tenants shared in the crop that was produced. The individual land ownership in these cases ranged from a single farm unit to a hundred or more in some instances. This reduced tremendously the number of interviews that were necessary to get an overall picture of the situation.

This survey, together with the tabulation of results, required approximately three months, and the small cash outlay required was borne by the two chambers of commerce. Some surprising results developed, one of which was that the majority of large landlord owners appeared as much or more interested in improving their properties as did the operating owners. In fact, a number of the latter group expressed but little interest in the idea as a whole, particularly that of putting in spare time to assist in carrying on such improvements. They seemed to feel that the production of a crop, along with other necessary operations on their farms, was as much as they should be expected to do. For the most part, however, both the farmers

and landlords of this county seemed genuinely interested in the proposed plan as was indicated by the number of inquiries over a period of months following completion of the survey as to the progress of the project.

The completed tabulation indicated what was needed to be done; how to do it was the next consideration in order. This finally took the form of an organized, business-like modernization of the community log rollings and house raisings that some of us have heard our grandfathers talk about. The county was divided into several areas, each as nearly uniform as to the type of farming carried on and therefore as nearly similar as regards farm plants and general conditions as could be roughly approximated. In each area it was proposed to organize a non-profit cooperative stock company to which each interested farmer, to the number of 200, could subscribe for stock in any amount up to the estimated cost of his improvements. This subscription could be paid in cash, by notes payable annually over a period of years, by labor to the extent that it could be used efficiently, or by local materials that he might have available.

Each corporation was to be operated by a board of directors elected by the subscribing members. These directors were to draw no compensation, but a paid executive would be employed with sufficient staff to handle the actual administrative work. It was found that in some instances a capable staff was available within the subscribing group which would of course reduce the cash outlay.

It would be of no especial interest to go into all of the details of the proposed operations of the corporation, since procedures suitable to conditions in that county would not be generally applicable. However, a few samples indicative of the care taken in developing this project may not be amiss.

In some sections of the county there was ample saw timber and also what would be otherwise idle sawmill time available to supply much of the necessary lumber required. Subscribing owners of this timber were to be given credit for the stumpage at an agreed price; subscribers with teams or trucks would be credited for hauling logs to and lumber from the sawmill, the owner of which while perhaps being paid in cash for its use would be furnished labor for its operation from that subscribed by stockholders of the corporation. In some sections of the county building stone of good quality was available for foundations and chimneys for only the labor of quarrying and transporting. In one section, however, it was proposed to operate a small idle brickyard on a cooperative basis.

The utilization of local materials was to be held within reasonable limits. It was considered that time was too important a factor to permit the hand processing of materials to anything like the extent that our grandfathers did, even if labor for the purpose was available. The estimated cost of outside manufactured items was nearly two-thirds of the estimated total value of material. These items were to be purchased with cash or its equivalent through normal procedure, and this was the stumbling block for the operation of the project as a relief measure. Emergency funds legally could not be made available for either a loan or a grant for the purpose at that time, nor were private funds to be had.

It was proposed to standardize the actual construction work as far as possible and carry it on during periods of the year when the largest amount of surplus labor would be available. The time required for preparation for operations, including that for production of foundation and framing materials, would give an opportunity for a greater detailed study of the individual farm requirements. Plans and suggestions from the agricultural extension service and other public and private agencies and organizations were to be utilized in attempting to get the best value possible for the expended funds and labor. The organization of construction crews, delivery of materials to the various jobs, and the actual building operation were to be handled under normal building contracting procedure.

This plan while potentially national in scope may be applied initially on an extremely limited and localized scale. It may be applied in a small district, to a county, over a state or group of states, as conditions may indicate. Properly organized and developed, it will bring into the setup all individuals, organizations, and groups that have an interest in the matter either directly or indirectly.

Many may say the proposition would never have worked out satisfactorily, that it is entirely too involved and impractical. Perhaps so. However, it did accomplish one very definite thing. It determined the size and scope of the problem in that county. This in itself is more than has been accomplished through any other means with which I am familiar. Farmers' cooperatives for other purposes have been operating successfully for many years. Possibly they could be made to work for this purpose. If this plan, modified to suit local conditions, is not a practical approach to the program that we have in mind, my hope is that it has sufficient basis of merit to bring out intensive constructive criticism from the many individuals who are much more competent to pass on the merit of a plan of this sort than I am. Thus perhaps we can get it torn up, added to, subtracted from, and reassembled into some form that is workable.

But whatever may be the plan decided on, please bear in mind that although we do not know the actual potential volume and scope of this postwar farm building program, we do know that it is large. We also know that the larger it is, the greater the benefits that will accrue to our national economy by successfully carrying it out. In this one Ala-

bama county tabulations indicated that even at prices for labor and materials prevailing in 1934, an expenditure of $873,000 would be needed to bring the farm buildings up to even the comparatively low standards that prevail on southern farms. If this were an average Alabama county in this regard, a similar expenditure in the state of nearly $60,000,000 would have been justified. Applied to the 3000 counties in the nation, it would amount to more than two and a half billion dollars. Even this is big business in anyone's vocabulary. But due to continued depreciation and lack of new construction, together with vastly increased prices for labor and material since 1934, the dollar value estimated for that date probably should be multiplied by three for postwar consideration.

My own guess with nothing tangible to back it up, although I have searched diligently for such data, is that $15 billion expended efficiently on the six million farms in the nation for repairs, modernization, and new construction of farm plants during the ten-year postwar period would no more than raise the farmer's standard of living and the efficiency of his operations to a par with those found in industry. But if it is only half this amount or even less, to plan, organize, and carry such a program to a successful conclusion will require far more than even the all-out individual efforts of the few agricultural engineers that are now available for work of that nature. These men and women —I would include home demonstration agents and similar groups—must become a great deal more than mere technicians. They must become the administrative agents of a far-reaching organization that includes the best possible talent available from all sources, if they are to handle this opportunity and the responsibility that goes with it in a way that may be classified as engineering.

THE IMMEDIATE TASK SHOULD NOT BLIND VISION TO THE WIDER OPPORTUNITIES FOR SERVICE

Some time ago an extension engineer of my acquaintance developed a certain useful farm gadget, but one that had rather local application. An ingenious farmer, by making trips to a junk yard, a hardware store, a lumber yard, and to his wood lot, could with what appeared to be a small outlay of cash secure the necessary material which, with a great deal of labor, he could assemble into a workable unit. For a year or more this engineer used a considerable portion of his field time explaining this gadget and his method of manufacture and use to individual farmers. Finally one farmer took the drawing to the proprietor of a small manufacturing plant in a near-by town and asked for the price on one completely fabricated. He was surprised to learn that in lots of ten or more the total cost of each would be but little more than the cost of only the material for a single one. This resulted in the distribution and use of more of these gadgets in one year than the individual efforts of the engineer would have secured in ten.

This probably is an exceptional case, but the fact remains that many agricultural engineers and others who guide the farmers' thinking have a decided tendency toward an individualized approach to any problem which develops. Thus the details of the immediate small task often obscure or blind the vision of what may be a much wider opportunity of service.

Some of us in industry feel that prefabricated structures may become an important factor in this postwar development. Last January a group from this organization, representing several phases of the building construction industry, asked the federal department of agriculture to furnish through proper agencies authoritative recommendations of optimum requirements for the proper functioning of certain farm buildings. It was frankly explained that the purpose of this was to obtain essential data to submit to engineers in industry, from which they might attempt to design these structures of a type suitable for factory fabrication. It was also pointed out that with the wide variation now existing among the recommendations made by specialists and agricultural engineers as to such requirements, mass production which is a first requirement for low cost in prefabrication is not feasible.

THERE WILL BE IN EXISTENCE A WELL-ESTABLISHED AGENCY FOR POSTWAR FARM BUILDING

Officials of the USDA gave attentive favorable consideration to the request and appointed committees from among their number to develop the information asked for. A recent letter states that this work is being carried on as rapidly as direct war activities permit.

In this connection, it may be of interest to some of you to learn that the demand for war housing units has provided an opportunity for a tremendous expansion of prefabrication in that particular field. From a negligible number through all the years including 1940, this type of construction was used for about 20,000 dwelling units in 1941, and it is estimated that more than 50,000 such units, or 20 per cent of the total structures of all types, will be erected in 1942. Thus at the close of the war there will be in existence a well-established, well-equipped, and strongly financed agency available for immediate postwar building construction. In addition there is a possible conversion of some of the strictly war-developed industrial plants to peacetime building prefabrication on a large scale.

Steel and other critical materials which now are not available for other than direct war uses, except in limited quantities, will then be available in greater quantity and better quality than ever before. Certainly it is not unreasonable to forecast that current industrial developments will be successfully put into future low-cost building construction, including that on the farm, these materials that for years have, as a matter of course, been considered basic to the manufacture of automotive equipment, ships, railroad cars, and hundreds of other familiar items.

But whatever classes of materials and methods of assembly may be employed, whether factory or handicraft; whether individual or cooperative or, as well may be the case, various combinations of all these, I suggest that no time be lost in developing some plan of operations that is sufficiently broad and comprehensive to include all necessary factors to do this big job in a big way. To do that all of us who are interested in the farm building construction problem who are not yet involved directly in full-time war work should, so far as possible, put aside all less important matters and concentrate on the solution.

And now let me submit two statements in conclusion. The first is that if we, as agricultural engineers, together with agricultural specialists and associates who are interested in farm buildings, will rise to the occasion of taking advantage of this wide open opportunity to get done for the farmer on a large scale and in an organized efficient manner even a considerable portion of the things that we so vociferously have been insisting that he needs, then we will attain and deserve a much greater sphere of influence and importance in the national agricultural economy than we have enjoyed in the past. The second is that if we fail to measure up to this opportunity, the postwar farm building construction program may lack much in developing the volume and efficiency that it might otherwise have attained, and that much of the responsibility for such a lack, whether rightly or wrongly, will rest on our shoulders.

Baling Straw Left by Combine

By A. L. Young
MEMBER A.S.A.E.

THE TESTS referred to in this paper were made primarily to secure and compare cost data of different methods of baling straw left in a windrow by a combine, using a pickup baler. Cooperating were the commodity development and agricultural residue divisions of the Northern Regional Research Laboratory (USDA), the University of Illinois, the J. I. Case Company, and B. C. Kern, operator of the farm on which the tests were made 12 miles north of Springfield, Illinois. Mr. Kern and the Case Company furnished all equipment except that supplied by the university for measuring grain losses in combining. Representatives of the regional laboratory recorded data needed for calculating costs.

Tests to compare three methods of combining and saving the straw were made. In Test A the 6-ft combine was operated to cut with a low (5-in) stubble, the straw left in a windrow, and this windrow baled with the pickup baler. In Test B the combining was kept as nearly as possible as in Test A, but an attachment was used whereby two windrows of straw were thrown together, making a double windrow. The baler had to travel much more slowly while taking up this double windrow, and occasionally the tractor pulling the baler would have to be stopped momentarily until the pickup baler and feed mechanism had time to clear. In Test C the combine was operated to leave a stubble of normal height (11 to 14 in), and the straw left in a windrow. The tractor pulling the baler (a larger tractor than that used in the other tests) was equipped with an 8-ft mower with a curved bar windrowing attachment.

The stubble left by the combine was mowed, and it as well as the straw left by the combine delivered by the windrower to the pickup of the baler.

The combine was checked for grain losses when cutting both a low and a high stubble. Observers kept a record of the time required for each operation keeping separate (1) the actual operating time, (2) time required for turning at the ends, and (3) time when motors were idling. Fuel for each operation was determined by completely filling fuel tanks at the start and weighing the fuel required to refill them at the end. Areas were measured with a surveyor's tape. To simplify measuring, all plots were made the same length, 1243 ft, so that only widths had to be measured as the work was done. Each test consisted of six rounds or twelve trips across the field with the combine. The baler made only three rounds when picking up the double windrows, and five when mowing stubble with the 8-ft mower.

The tests were made July 7 to 8, 1941 in a better than average field of wheat on level black loam soil. The Turkey Red wheat leaned only slightly, was ripe and dry, and contained no green undergrowth except clover so short that very little was clipped even when combining at a height of 5 in. Weather was clear and warm with a light wind. Field, crop, and weather conditions were near ideal, although the ground was perhaps slightly softer than normal because of rain some three days before.

The grain losses when combining were determined in the usual way, by catching straw and chaff on separate canvasses held back of the machine while it traveled distances that averaged about 150 feet. Grain delivered by the combine was caught in a sack at the same time. The straw (after weighing) and the chaff were rethreshed in a small two-cylinder test thresher to recover grain left in them by the combine. The cutter bar or harvesting loss was calculated by picking up all grain left on five square areas chosen at random on the test strip, the total of these areas being 75.1 sq ft.

The combine used was a new Case Model G, 6-ft cut, with rasp type cylinder and engine. It was pulled by a Case SC tractor. The baler was a Case NCM pickup type with motor. It was pulled by a Case VC tractor, except for Test C when the SC tractor with mower was used. A home-made dumping two-wheel trailer was pulled back of the baler, and the bales stacked on it, the bales being dumped on the ground in piles of approximately six each. The bales weighed about 60 lb, or 8.62 lb per cu ft. Four men were required to operate the baler—one on the tractor, two to tie the bales, and one on the trailer. One man operated the combine.

Paper presented December 1, 1941, at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill. A contribution of the Power and Machinery Division. Author: Associate professor of agricultural engineering, University of Illinois.

Two views of the equipment used in the straw baling tests reported by A. L. Young in the accompanying paper. (Left) The high stubble left by the combine is being mowed here by a semimounted mower attachment on the tractor, after which it is picked up and baled, the operations of mowing, windrowing, and baling being therefore performed at one time. (Right) In this picture, the combine on the right is throwing the straw, by means of a makeshift deflector, into a double windrow, and on the left the baler is baling the straw from the windrows. The trailer wagon dumps a number of bales in a pile which saves much time when the bales are gathered

It will be noted that the total loss of grain was less when cutting with a 5-in stubble (Tests A and B) than when the stubble was 11 to 14 inches. In this case the reduction of the cutter-bar loss, due to lower cutting, more than offset the slight increase in the loss in the straw and chaff caused by the greater amount of straw. This would not always be the case. If operating to secure a low stubble causes large amounts of green material to pass through the combine and results in high grain losses and high moisture in the threshed grain, it would probably be more satisfactory to cut a high stubble, and, if desired, mow the stubble as was done in Test C.

ESTIMATED COST OF BALING STRAW FROM WINDROW LEFT BY COMBINE

(Bales Left in Field in Piles of Six)

Test	A	B	C
Acres in test area	1.87	1.89	1.74
Combine — Case G, 6-ft			
Average width of cut, ft	5.5	5.52	5.5
Height of standing wheat, in	33-43	33-43	33-43
Height of stubble, in	5	5	11-14
Rate of travel, mph	2.8	2.5	3.3
Rate of harvesting, acres per hour	1.85	1.71	2.1
Bushels per acre threshed	31	31	31
Pounds of straw per minute through combine	93	93	67
Size of windrow	Single	Double	Single
Grain lost in straw and chaff, per cent	1.3	1.6	1.0
Grain lost in straw and chaff, bu/acre	.39	.51	.31
Grain lost by cutter bar, per cent	.6	.7	1.7
Grain lost by cutter bar, bu/acre	.18	.24	.54
Grain lost (total), per cent	1.8	2.3	2.7
Grain lost (total), bu/acre	.57	.75	.85
Moisture in threshed grain, per cent	12.4		13.0
Moisture in straw from combine, per cent	10.4	9.9	10.0
Baler — Case NCM with motor			
Tractor pulling	Case VC	Case VC	Case SC
Average width of strip per thru, ft	5.5	11.04	6.1
Rate of travel, mph	3.5	2.0	2.7
Rate of baling, acres per hour	2.0	2.3	1.7
Rate of baling, tons per hour	2.0	2.8	1.4
Rate of baling, tons per acre	1.00	1.23	.84
Straw and chaff determination (1 bale):			
Chaff (all passing through a 4x4-in mesh), per cent	2.5	3.7	
Straw, per cent	97.5	96.3	
Baler costs			
Investment	945.00	945.00	945.00
Interest, annual (5% of one-half investment)	23.60	23.60	23.60
Interest per ton (500 tons per year)	.047	.047	.047
Taxes, insurance, shelter (annual)	10.00	10.00	10.00
Taxes, insurance, shelter per ton	.02	.02	.02
Depreciation, annual (10% of investment)	94.50	94.50	94.50
Depreciation, per ton	.189	.189	.189
Gasoline per ton, gal	.55	.39	.76
Fuel cost (at 12c per gal), per ton	.066	.047	.091
Oil and grease, per ton	.01	.01	.01
Repairs, annual (2% of investment)	18.90	18.90	18.90
Repairs, per ton	.038	.038	.038
Wire, per ton	.45	.45	.45
Total, per ton	.82	.80	.85
Tractor (pulling baler) costs			
Investment	755.00	755.00	1020.00
Interest, annual (5% of one-half investment)	18.75	18.75	25.50
Interest, per hour (600 hr per year)	.312	.312	.425
Interest, per ton	.156	.113	.305
Taxes, insurance, shelter (annual)	10.00	10.00	10.00
Taxes, insurance, shelter, per ton	.01	.004	.018
Depreciation, annual (10% of investment)	75.50	75.50	102.00
Depreciation, per ton	.063	.046	.122
Gasoline per ton, gal	.41	.40	.78
Fuel cost per ton	.049	.048	.094
Oil and grease, annual	12.00	12.00	15.00
Oil and grease, per ton	.01	.007	.018
Repairs, annual (2.5% of investment)	18.85	18.85	25.50
Repairs, per ton	.015	.011	.030
Total, per ton	.303	.231	.587
Trailer costs			
Investment	50.00	50.00	50.00
Total cost per ton (500 tons)	.01	.01	.01
Mower and windrower (curved bar) costs			
Investment (windrower, $8.00)			278.00
Interest, annual (5% of one-half investment)			6.95
Interest, per hour (100 hr per year)			.069
Interest per ton			.050
Taxes, insurance, shelter (annual)			3.00
Taxes, insurance, shelter per ton			.022
Depreciation, annual (10% of investment)			27.80
Depreciation, per ton			.20
Repairs, annual (5% of investment)			13.90
Repairs, per ton			.10
Oil and grease, per ton			.005
Total, per ton			.38
Labor costs			
Man-hours per ton (4 men)	2.03	1.45	2.88
Cost (at 30c per hr), per ton	.61	.43	.86
Total cost per ton	1.74	1.47	2.69

An attempt has been made to calculate the cost per ton, for each of the three tests, of baling the straw and leaving it in piles as the bales were dumped from the trailer. These, of course, are very short tests. The equipment was new and operated in part by company men more expert than the average farm operator. As stated before, conditions were very favorable for doing the work quickly and with a minimum of trouble.

The time required for turning at the ends and when engines were running idle was probably a little more than normal, the first because of not cutting across the ends of the plots and the latter because of stops to take pictures and do other things necessary for a complete record. To correct for this only one-half of each of these as recorded was included when calculating the total time on which man-hours of labor was based.

Since the fuel as measured for a test included that used when turning at the ends and idling, a slight reduction was made because of the assumed extra turning and idling. This calculation was based on the assumption that the engines would use one-fourth as much fuel per unit of time when idling as when under load, and the baler engine one-half as much when turning at the end as when going across the field. The tractor engine, presumably, would use fuel as rapidly when turning at the end as at other times.

Numerous assumptions have had to be made with regard to annual use of the machines, probable years of life, costs of taxes, insurance, repairs, oil, and grease, and so on. It was attempted to have these consistent with data reported in other cost studies that have been published.

Presumably the results of Test B would indicate the advisability of making a double windrow when combines as small as this are used. For combines with 8-ft or larger headers it doubtless would not be advisable unless the growth of straw were light. If windrows as heavy as those in Test B are to be handled, it would be desirable to have a tractor with a minimum speed low enough to avoid the necessity of stopping because of over-loading of the pickup. The attachment used here for making the double windrow was a simple improvised slide of sheet metal attached to the rear of the combine. The regular equipment is also simple and inexpensive, but was not available for the tests. It is a small chute that can be shifted, from the operator's seat, to throw the straw first one way and then the other, and should not interfere with the operation of the combine.

Test C, in which the tall stubble left by the combine was mowed and both it and the straw from the combine baled, would appear to be, from the results obtained, a less desirable method than either of the other two. The lower yield in tons per acre as compared with the other two (0.84 ton as against 1.00 and 1.23 tons) is due to failure to deliver all the mowed stubble to the baler. The height of stubble left by the mower was 4 in, one inch less than that of the combine when cutting low.

Considerable of the additional cost of Test C as compared to the others was due to the use of the larger tractor. Possibly, when conditions were favorable, the smaller tractor might satisfactorily handle the additional load of mower and windrower. In this case a trailer-type mower was used. A mower with bar at the side of the tractor would permit attaching the baler directly to the tractor and possibly allow slightly faster travel than in this test. The lower acres per hour and the lower acre yield of straw for Test C, as well as the additional costs of the larger tractor and the extra equipment, have made the ton cost considerably more than for either of the other methods, $2.69 per ton as against $1.74 for the single and $1.47 for the double windrow in Tests A and B. *(Continued on page 389)*

Movement of Soil During Tillage Operations

By S. J. Mech and G. R. Free
MEMBER A.S.A.E.

THE DEVELOPMENT of benches during contour cultivation of such permanent crops as orchards and vineyards, and the observed movement of soil during cultivation prompted this study of the mechanical movement of soil. The object was to obtain measurements of soil movement caused by certain farm implements on different slopes and for different directions of travel. Emphasis was placed on movement up or down the slope.

It has been generally recognized that there can be an appreciable movement of soil during tillage operations. In Puerto Rico, where very steep slopes are farmed, bench terraces may be formed in 3 to 5 years by the normal process of preparing land and cultivating crops[1]*. In California such terraces may be formed in orchards in 10 years[2].

McGrew and Horner[4] report: "On steep slopes (above 20 per cent) the tillage implements will not turn the furrows uphill and all tillage gradually moves the topsoil down the slope. During the past 50 years, it is likely that at least 6 in of topsoil has been moved a distance of not less than 25 ft."

It is apparent that while soil movement during tillage has been generally recognized and appreciated, there is a lack of experimental data concerning such movement. Soil movement downhill is desirable and necessary in the formation of benches, but in general it is an undesirable result of tillage and should be minimized as much as possible.

A single section of a springtooth harrow was used for a preliminary study up and down a 19 per cent slope. The harrow was pulled in operating position into a box of graded and painted gravel sunk flush with the soil in the path of travel. The box had removable ends so that the harrow could enter the box while still set to operating depth. The entire harrow was lifted after it entered the box so that any soil carried by it was left in the box. This soil was then separated from the gravel and weighed. For subsequent tests a weighed quantity of soil was placed in the box instead of the gravel. The amount of soil carried by the harrow was then indicated by the difference between the weight of the soil in the box before and after the test. This eliminated the necessity of separating the transported soil from the gravel.

These procedures were satisfactory for measurements of soil movement along the line of implement travel, but they were not suitable for studying the soil movement up or down the slope when the direction of travel was across the slope. In order to study this problem the following procedure was developed.

A box 4 ft square (Fig. 1) was filled with soil to a depth of approximately 6 in. One end of the box rested on a platform scale while the other end was supported by a chain hoist which permitted an adjustment to any desired slope. The implement under test was fastened to a board which was then moved across the box to accomplish the desired tillage.

With the box level, or at zero slope, the soil was raked and leveled, and the reading of the scale was obtained. The hoist end of the box was then raised to give the desired slope, and the specific tillage operation was performed. The box was then returned to zero slope and the new scale reading or reaction recorded. If this reaction was greater than the initial reading, the soil had moved downhill towards the scale. If the reading was less than the initial, the soil had moved uphill away from the scale. The magnitude and direction of the change in scale reaction resulting from any tillage operation indicated the magnitude and direction of soil movement.

Each run on the contour consisted of five trips across the box, but only four trips were made for a run up or down the slope. The center trip had to be omitted because the scale and hoist were in the path of travel of the board carrying the tillage unit. The length of travel per trip was necessarily different for each tool because of the different distances required to get them into and out of the soil. For these reasons the reactions were converted to soil movement in foot-pounds per foot of travel. By the principle of moments, the change in the scale reaction (R) multiplied by the span between scale support and hoist (S) equals the product of the weight of soil moved (W) and the distance it was moved (D). Thus $RS=WD$. The product RS divided by the distance the implement traveled to produce the change in reaction was equal to the soil movement in foot-pounds per foot of travel. All reactions were expressed in pounds and all distances in feet.

This calculation made possible direct comparisons of the ability of the different implements to move soil when they operated either up the slope, down the slope, or on the contour. These data were obtained for three tools (a reversible cultivator shovel, a duckfoot cultivator shovel, and a small turn-plow) on slopes of zero, 10, and 20 per cent on Honeoye silt loam topsoil.

Between series of runs the soil was sprinkled and then allowed to dry to moisture content satisfactory for operation. Soil moisture samples during the runs ranged between 19.3 and 24.5 per cent of dry weight. The average was 21.1 per cent. No measurable effect of moisture variation within this range was noted.

Data were secured for the small turn-plow of the wheel-hoe type, although it was realized that operation of this unit in loose soil did not simulate the conditions of field plowing.

Investigations of soil movement resulting from contour field plowing were conducted using the equipment shown in Fig. 2. This equipment was designed to measure the plow furrow before and after it was plowed. It consisted of a two-by-four about 16 ft long with a box cover on one end so that it could be butted up against and on top of a reference stake. The other end of the two-by-four rested on another stake the top of which was at the same elevation as the first. A frame carrying 40 wooden dowels, each graduated to 1/10 ft, was clamped to this two-by-four. These dowels, free to move up or down, were 1/10 ft apart, and the position of each dowel with respect to the reference stake was known.

A Farmall No. 86, two-way, 14-in plow mounted on a Farmall F-12 tractor was used. After two or three starting

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*Superscript numbers refer to the references appended to this article.

furrows had been plowed, the measuring equipment was used, and the position of each dowel and the ground elevation at that point were recorded. Such cross-sectional measurements were made at several points along the furrow. This was repeated as other furrows were plowed. The profiles of furrows and furrow slices were then plotted and provided an average section of cut, furrow, and furrow slice for that slope and direction of throw.

A few tests were made on a single slope to measure soil-moving capacity of the same plow along its path of travel. These tests were made in a manner very similar to that used to determine the transporting capacity of the springtooth harrow.

Results with Harrow. The springtooth section used in the preliminary study had 9 teeth, each 1¾ in wide, arranged in 3 rows of 2, 3, and 4 teeth each. Its width was about 36 in so the average effective tooth spacing was 4 in. The harrow was operated at a depth of approximately 4¾ in.

It was found that 109.4 lb, or 12.2 lb per tooth, were carried along with the harrow when it was pulled down a 19 per cent slope and only 43.8 lb, or 4.9 lb per tooth, when the harrow was pulled up the slope. These values may be called either transporting capacity expressed in pounds, or soil movement per foot of travel expressed in foot-pounds since the direction of soil movement and travel of the implement were the same.

Results with Cultivator Shovels. Typical furrows produced by a single reversible shovel are shown in Figs. 3, 4, and 5. The data in Table 1 indicate that soil movement was 1.4 ft-lb per ft of travel up the 20 per cent slope and 2.8 ft-lb per ft of travel down the slope. The 2.8 ft-lb of soil movement is equivalent to moving 2.8 lb of soil 1 ft or moving 1 lb of soil 2.8 ft since soil movement is the product of mass times distance.

In Fig. 4 are shown furrows produced with the same cultivator shovel when the box and soil were at zero slope. Note that about the same amount of soil was moved to the right as to the left. Actually the amounts differed slightly as indicated by the data in Table 1. This variation was probably caused by a slight misalignment of the tooth on the board.

Corresponding furrows for contour travel on a 20 per cent slope are shown in Fig. 5. Note the pronounced difference in the amounts of soil thrown uphill and downhill. The data in Table 1 indicate that there was 0.9 ft-lb of soil movement per foot of travel on the 20 per cent slope.

The soil movement data in Table 1 are for soil movement up or down the slope only. When harrow or cultivator teeth which are symmetrical move up or down the slope, there is also soil movement to the right and left of the path of travel, but these movements are equal. Likewise when operations are being performed on the contour, there is soil movement in the direction of travel as well as up and down the slope, but the soil movement in the direction of travel for one trip across the slope is cancelled on the return trip.

Corresponding data for the duckfoot cultivator shovel are also given in Table 1. This shovel moved significantly greater quantities of soil downhill when traveling in that direction than the other type of shovel.

In making a comparison of the net soil movement downhill resulting from operations on the contour and that resulting from operations up and down the slope, it is necessary to add algebraically the uphill and the downhill data and compare this sum with twice the contour data since an uphill and downhill cultivation would be equivalent to two cultivations. These comparisons are given in the last two columns of Table 1.

Results with Small Turn-Plow. The data for the turn-plow are also presented in Table 1. Soil was moved uphill when turning furrows uphill in this loose soil only on the zero and 10 per cent slope. When the furrows were turned uphill on the 20 per cent slope, the net movement was downhill. This was due primarily to the loose condition of the soil.

Field Plowing. The data from the soil movement study of field plowing on three land slopes are presented in Table 2. During this part of the study the plowing depth was between 6 and 7 in. The tilt of the plows was the same throughout all tests. The resulting width of cut was greatest when turning furrows downhill on a 16.9 per cent slope and least when turning furrows uphill on a 16.9 per cent slope.

The soil movements per foot of travel range from 46.7 to 67.8 ft-lb and are of course far greater than those for the other implements tested. It was expected at the start of this phase of the study that there would be more of a trend in soil movement with respect to land slope and direction of throw. The amount of soil movement when furrows were turned uphill on the steepest slope was only 31 per cent less than when the furrows were turned downhill. The width of the land cut was 20 per cent less.

It was noticed during the tests that the furrow slices, when turned uphill on the steepest slope, were more nearly vertical than in any of the other tests. The angle with the horizontal for all tests except this one ranged from 36 to 43 deg (Table 2). This angle when turning furrows uphill on the 16.9 per cent slope was 56 deg, or more than a 1 to 1 slope. The upper limit of slope for turning furrows uphill with that plow and plow adjustment had been nearly reached.

Considering the number of tillage operations performed, it is apparent that mechanical movement of soil

TABLE 1. SOIL MOVEMENT UPHILL OR DOWNHILL PER LINEAR FOOT OF TRAVEL*

Implement	Land slope, per cent	Direction of Operation: Contour, ft-lb	Uphill, ft-lb	Downhill, ft-lb	Uphill plus down, ft-lb	Two times contour, ft-lb
Reversible cultivator shovel**	0	—0.1	—2.0	+2.0	0.0	—0.2
	10	+0.5	—1.9	+2.4	+0.5	+1.0
	20	+0.9	—1.4	+2.8	+1.4	+1.8
Duckfoot cultivator shovel***	0	—0.1	—2.4	+2.4	0.0	—0.2
	10	+0.5	—2.0	+3.1	+1.1	+1.0
	20	+1.0	—1.6	+3.9	+2.3	+2.0
Small turn-plow†	0	—1.3††	—5.3	+5.0	—0.3	—2.6††
	0	+1.2†††				+2.4†††
	10	—0.2††	—3.6	+4.7	+1.1	—0.4††
	10	+1.9†††				+3.8†††
	20	+1.0††	—3.3	+5.4	+2.1	+2.0††
	20	+2.9†††				+5.8†††

Least difference in columns 3, 4, and 5 which can be considered significant (5 per cent point) is 0.4 ft-lb.

*Plus signs indicate soil movement downhill and minus signs indicate soil movement uphill.

**Width of shovel, 2¼ in; operating depth in soil, 3 in.

***Width of shovel, 8 in; length of sweep, 7½ in; operating depth in soil, 2¼ in.

†Width of plow, 4 in; operating depth in soil, approximately 3 in.

††Furrow slice turned uphill.

†††Furrow slice turned downhill.

downhill under the usual farming practices can add considerably to the soil moved by flowing water. The movement of soil during tillage and that during the erosion process are different in many ways. The former is largely a mass movement, and the latter is largely a selective movement of the finer particles. Middleton, Slater, and Byers[5] state, "When the quantity of eroded material is large, it is similar in character to the whole soil. When the erosion is slight, the fine material predominates." Data[3] from the Arnot station near Ithaca, New York, indicate that stones larger than ¼ in constituted 60 per cent of the soil on a plot and only 3 per cent of the soil lost in runoff. It is apparent then that the soil moved during tillage operations could be moved back to its original position, but it would be impossible to replace the eroded material as it was originally. Both removal and deposition are selective in the case of erosion. In general, erosion losses are measured at the bottom of a slope and represent an actual loss of soil from the area above. It is, however, generally recognized that there has been movement of soil *on* the area *in addition* to that moved off and measured. It is possible also to have soil movement or soil erosion although no soil loss could be measured.

Let us consider the topsoil as a blanket. When the field is plowed across the slope turning furrows downhill, or when it is harrowed or cultivated, this blanket is moved down the slope. Topsoil will be moved away from its upper edge, and because of the difference in soil movement where the land slope changes, the blanket will be wrinkled or thickened at any point where the slope is decreased.

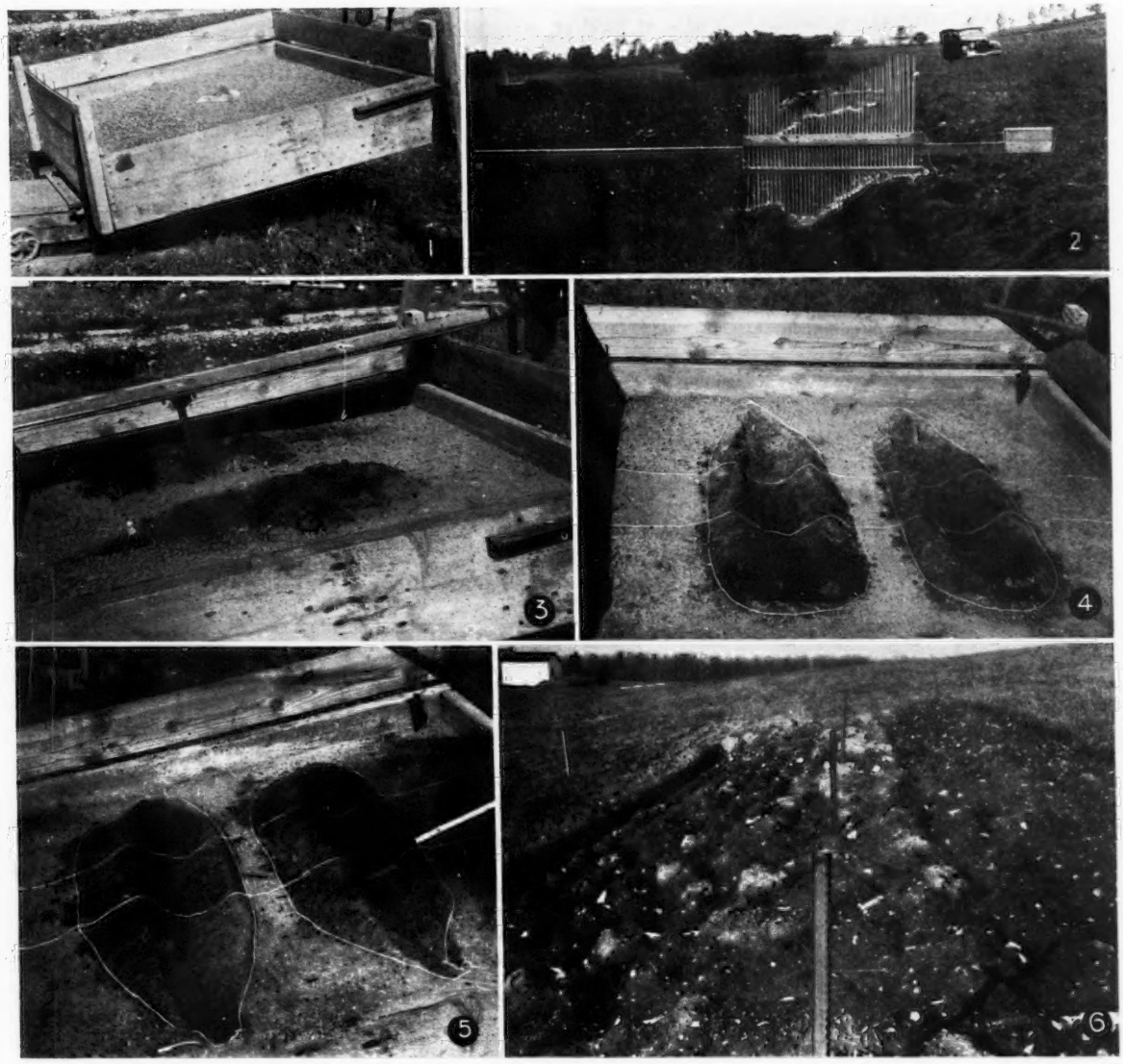

Fig. 1 Equipment used to determine the soil movement produced by certain tillage operations • Fig. 2 Equipment used for measuring soil movement resulting from contour plowing • Fig. 3 Results of cultivating up or down a 20 per cent slope. The furrow in the foreground was produced by pulling the shovel up the slope while the furrow in the background is being produced by pulling the shovel down the slope • Fig. 4 Results of cultivating on a zero per cent slope. Note equal banks on both sides of the furrow • Fig. 5 Results of contour cultivation on a 20 per cent slope. Note the large amount of soil moved down the slope • Fig. 6 A comparison of the soil surface condition resulting from contour plowing on a 16.9 per cent slope. Furrows on the right were turned downhill and those on the left were turned uphill. Plowed October 8 and photograph taken 1½ months later. Furrows turned uphill probably provide more resistance to erosion

TABLE 2. SUMMARY OF PLOW FURROW DATA

Direction furrow was turned	Land slope, %	Furrow depth, ft	Width of cut, ft	Cross section of cut, sq ft	Cross section of slice, sq ft	Area slice to area cut, ratio	Soil moved per ft of travel,* lb	Distance moved up or down the slope,** ft	Soil movement up or down the slope,*** ft-lb	Slope of slice compared with horizontal, deg	Soil moisture, %
Downhill	16.9	0.54	1.15	0.62	0.93	1.50	44.6	+1.52	+67.8	36	16.2
"	9.8	.54	1.07	.58	.80	1.38	41.8	+1.35	+56.4	37	13.8
"	5.4	.56	.97	.54	.74	1.37	38.9	+1.42	+55.2	40	21.5
Uphill	5.4	.57	.99	.56	.80	1.43	40.3	—1.45	—58.4	43	21.5
"	9.8	.51	.95	.48	.70	1.46	34.6	—1.35	—46.7	41	13.9
"	16.9	.52	.92	.48	.70	1.46	34.6	—1.35	—46.7	56	16.2

*Weight of dry soil per cubic foot, 72 lb.
**Change in position (up or down slope) of the center of gravity of cross section. Plus signs indicate movement downhill and minus signs indicate movement uphill.
***The product of the pounds of soil moved per foot of travel and the distance moved up or down the slope.

Recognizing that there are these differences between erosion and soil movement caused by tillage, it is still interesting to make comparisons of the two processes on a soil movement basis.

Let us consider a plot 20 ft wide and 100 ft long, and assume that the measured soil loss from erosion is 92 lb which is equivalent to one ton per acre. This is the weight of the soil, but the travel distance is unknown. However, data from various experiment stations of the Soil Conservation Service indicate that soil loss per unit area is generally increased when length of slope is increased. Therefore, it must be concluded that soil removal is not uniform over a plot and that the amount of soil removed must increase as the bottom of the plot is approached, or at least more soil must be moved from the bottom half of the plot than from the upper. It would seem a safe assumption then to place the average distance that the 92 lb are moved at something less than halfway, say 33⅓ ft. The one ton per acre then equals 92 times 33⅓, or 3067 ft-lb of soil movement.

Now let us return to a consideration of the total soil movement on the plot that would result from plowing the plot on the contour and turning the furrows downhill. The data in Table 2 indicate that the soil movement per foot of travel on a 16.9 per cent slope was 67.8 ft-lb. The width of cut was 1.15 ft, so the length of travel in plowing the plot would be approximately 1700 ft. The amount of soil movement would be 1700 times 67.8, or 115,260 ft-lb. This is 37.6 times the soil movement represented by the erosion loss of one ton per acre when we neglect the unmeasured movement on the plot.

If the whole bottom furrow had been turned into the catchment equipment, the *weight* of soil would be 20 times 44.6, or 892 lb. This is approximately 10 times the erosion loss of 92 lb. In this last comparison, doubling the length of plot would ordinarily mean that the weight of soil removed during erosion would be at least doubled, but the weight of soil turned into the catchment equipment during plowing would remain the same. The soil movement resulting from one harrowing up and down the slope would be approximately 7 times that represented by the soil loss of one ton per acre.

It is not the purpose of this discussion to minimize the erosion problem since it is of the utmost importance, nor to question the value of contour operations since they are necessary for erosion control. Our sole aim is to emphasize the importance of mechanical movement of soil during tillage operations. Anything that can be done to decrease the amount of soil movement downhill is desirable, unless of course the aim is to produce a bench terrace as rapidly as possible.

Turning the furrow uphill during contour plowing appears to be the only way at present of compensating to any extent for the movement downhill which is associated with harrowing, cultivating, and the erosion process. Perhaps an added advantage of turning furrows uphill is shown in Fig. 6 taken about 1½ months after the plowing tests on the 16.9 per cent slope. The surface of the furrows turned downhill is considerably smoother than that of the furrows turned uphill. The furrows turned uphill probably provide more resistance to erosion than those turned downhill.

SUMMARY

1 Equipment and techniques for measuring soil movement during tillage operations have been described.

2 Soil movement downhill during harrowing and cultivating operations increased as the slope was increased.

3 A duckfoot cultivator shovel operated on the contour produced soil movement downhill approximately equal to that when it was operated up and downhill. A reversible cultivator shovel operated on the contour produced greater soil movement downhill than when it was operated up and downhill.

4 When contour plowing under field conditions there was very little actual difference in the amount of soil movement on different slopes. Soil movement uphill on a slope of 16.9 per cent when contour plowing and throwing the furrows uphill was 31 per cent less than soil movement downhill when throwing the furrows downhill, but the width of cut was 20 per cent less.

5 No difficulty was experienced in turning furrows uphill when contour plowing a 16.9 per cent slope. However, the angle of the furrow slices indicated that the upper limit of slope for turning furrows uphill was nearly reached.

6 On a 20x100-ft plot, turning the furrows downhill in contour plowing would produce soil movement 38 times as great as that represented by an erosion soil loss of 1 ton per acre from the plot when the unmeasured movement on the plot during the latter process is not considered. The bottom furrow on this plot, if turned downhill and off the plot into the catchment equipment, would *weigh* 892 lb which is nearly 10 times the weight of soil equivalent to an erosion loss of 1 ton per acre.

7 Turning furrows uphill during contour plowing was the only feasible form of operation that moved soil uphill to compensate to some extent for the unavoidable downhill movement during cultivating, harrowing, and erosion processes.

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The Effect of the Jacket Water Temperature on Crankcase Dilution and Fuel Economy of a Tractor Engine

By Arthur H. Thompson
JUNIOR A.S.A.E.

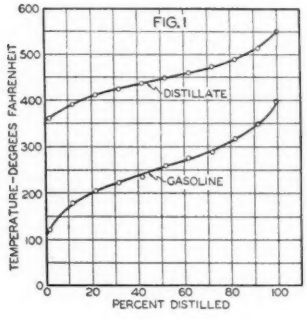
OF THE tractors on farms today 80 per cent are of the two-fuel type, that is, designed to burn either a heavy fuel or gasoline. But in the central states about 63 per cent of all the two-fuel tractors are operated entirely on gasoline, according to C. N. Hinkle, in AGRICULTURAL ENGINEERING for November 1941. If a tractor is equipped with an engine designed to burn distillate or other low-grade fuels, it should be operated on those fuels for best economy. Performance and fuel economy are improved when high-grade fuels are burned in engines designed for their use.

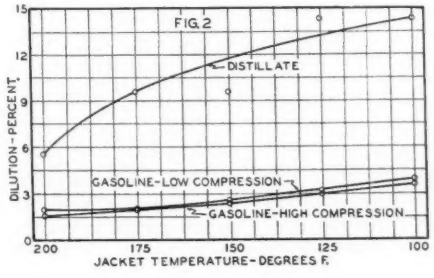
The main reason for burning gasoline in low-compression engines seems to be convenience. If distillate is burned, the engine must be started and warmed up on gasoline, and the operating temperatures must be carefully controlled thereafter. The distillation curves for gasoline and distillate shown in Fig. 1 explain why the engine temperatures must be higher for satisfactory handling of distillate. If the engine temperature is too low, the fuel will not vaporize and consequently cannot be burned. The fuel which does not burn may be carried from the combustion chamber with the exhaust gases, or it may enter the crankcase to dilute the lubricating oil.

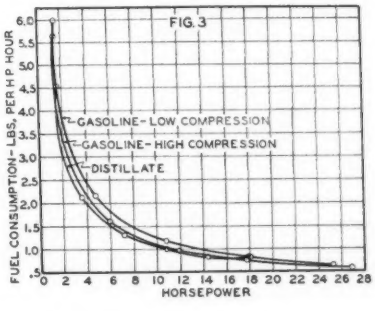
The engine temperature can be regulated on most tractors burning low-grade fuel by radiator curtains or by some other means of controlling the temperature of the jacket water. A series of tests were conducted at the University of Minnesota to determine the effect of jacket water temperature on crankcase dilution and fuel consumption. Tests were made with a vertical four-cylinder engine with 3¾-in bore and 4¼-in stroke with maximum power of about 30 hp at 1800 rpm. The engine could be equipped for a 5.90 to 1 compression ratio and a cold manifold for burning 70 to 72 octane gasoline or, by changing the head and manifold the engine could be equipped with a 4.75 to 1 compression ratio and a hot manifold for burning distillate. The distillate manifold had an adjustable heat valve so that the operator could quickly change from the hot to the cold manifold when both distillate and gasoline were burned in the engine. The same carburetor was used on the test engine for both gasoline and distillate.

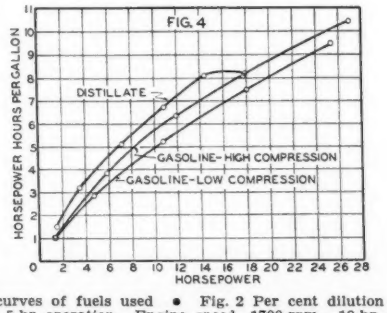
The engine was loaded and the power measured by a Sprague electric dynamometer. To control the jacket water temperatures a second radiator was mounted beside the original one, and the two were connected in series. The increased radiating area was sufficient to provide jacket water temperatures as low as 150 F (degrees Fahrenheit), but for lower temperatures it was necessary to add tap water to the cooling system. Tap water was added at the top of the second radiator, and an equal amount of hot water was drained from the bottom of the first radiator. With the aid of a radiator curtain it was possible to maintain temperatures as low as 100 F for long periods without more than 2 deg temperature variation. The jacket

Paper presented April 3, 1942, at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Shreveport, La. Author: Agricultural engineering department, University of Arkansas.









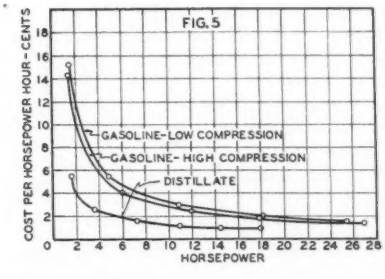


Fig. 1 Distillation curves of fuels used • Fig. 2 Per cent dilution of crankcase oil after 5 hr operation. Engine speed, 1700 rpm. 18 hp • Fig. 3 Curves showing the relative fuel consumption of the engine with the jacket temperature at 200 F for distillate and at 175 F for gasoline • Fig. 4 Horsepower-hours per gallon with the jacket water temperature at 200 F for distillate and at 175 F for gasoline • Fig. 5 Cost per horsepower-hour with the jacket temperature at 200 F for distillate and at 175 F for gasoline. Distillate, 8.3c per gal. Gasoline, 15.7c per gal

water temperature was measured by a mercury thermometer as the water passed from the engine jacket to the first radiator.

Tests were run with 73 octane gasoline burned with 5.9 to 1 compression ratio and cold manifold; with 33.5 octane distillate burned with 4.75 to 1 compression ratio and hot distillate manifold; and 73 octane gasoline burned with 4.75 to 1 compression ratio and distillate manifold with cold setting. An S.A.E. No. 30 oil was used in the crankcase for all tests. Further data on the fuels and oil are given in Table 1. The prices listed are retail prices for the fuels and oil in Minneapolis, Minnesota, on August 1, 1941.

TABLE 1. FUEL AND LUBRICATING OIL DATA

	Octane number	Specific gravity	Cost, cents/gal	Lb., per gal	Cost, cents/lb
Gasoline	73	.7397	15.7	6.169	2.545
Distillate	33.5	.8167	8.3	6.811	1.218
Lubricating Oil		.9242	39.0		

Viscosity of oil, 255 Saybolt seconds at 130 F

Engine tests run for the determination of crankcase dilution were five hours long, were made with a load of 18 hp, and an engine speed of 1700 rpm. The jacket water temperature was varied from 100 to 200 F. After the engine was warmed up, it was stopped, the oil drained, new oil added, and the engine started again immediately to begin the test. Operating conditions were kept as nearly constant as possible throughout the test. At the end of five hours the engine was stopped and the oil drained out immediately, a sample for determining dilution being collected as it drained from the crankcase.

The percentage dilution for all samples was determined by the standard A.S.T.M. method for determining dilution of crankcase oils when gasoline is used for fuel. Since this method is not standard for determining dilution with distillate, a check was made by determining the viscosity of the dilution samples.

Fig. 2 shows the results of the tests run to determine the effect of the jacket water temperature on the oil dilution of a tractor engine. When distillate was burned, the lubricating oil was diluted as much as 14.4 per cent in five hours when the jacket water temperature was held at 100 F during the test. When the jacket water temperature was held at 200 F, the lubricating oil was diluted only 5.6 per cent in five hours. Changing the jacket water temperature from 200 to 100 F increased the rate of dilution 2.5 times. The rate of dilution was increased 1.9 times by changing the jacket water temperature from 200 to 175 F, indicating a very definite advantage as far as dilution is concerned in operating at the higher temperature. When gasoline was burned, dilution of the lubricating oil by the fuel was considerably less in every case than when distillate was burned. However, in both series of tests where gasoline was used, the amount of dilution in five hours was doubled when the jacket water temperature was changed from 200 to 100 F. There was less dilution when gasoline was burned with a 5.90 to 1 compression ratio and cold manifold than when it was burned with a 4.75 to 1 compression ratio and distillate manifold. This was probably due to the higher compression pressures and consequent higher temperatures in the combustion chamber when the high compression head was used resulting in better fuel vaporization and less condensation on the cylinder walls. It is interesting to note that the oil dilution was 40 per cent more at the end of five hours when distillate was burned with the jacket water temperature at 200 F than when gasoline was burned with the jacket water temperature at 100 F.

Ten minute tests were made to determine the effect of the jacket water temperature on the fuel consumption of the engine with the engine burning distillate, and with the engine burning gasoline with both gasoline and distillate equipment. Tests were run with a number of loads, and the temperature of the jacket varied from 100 to 200 F at each load. The carburetor and spark were set for each fuel and engine equipment combination, but were not changed when the load or jacket temperature changed. All fuel consumption tests were run with the engine operating at rated speed, 1800 rpm.

In the fuel consumption tests it was found that when distillate was burned, the engine detonated rather severely when a load of more than 18 hp was applied. Detonation could be checked by opening the heat valve in the manifold, but if that were done, the conditions of the tests would be changed, and it would be impossible to compare the results. So when distillate was burned the maximum load applied was 18 hp. No detonation occurred at any time when gasoline was burned.

In almost every case, decreasing the jacket water temperature resulted in increasing the specific fuel consumption. The jacket water temperature was varied from 100 to 200 F in 25-deg steps, but since the increase in fuel consumption was small for each temperature change and there was no consistency in the amount of change in fuel consumption for each 25-deg temperature step made, only the increase in fuel consumption made by changing the jacket temperature from 200 to 100 F is tabulated. Table 2 shows the results of the tests run to determine the effect of the jacket water temperature on fuel consumption. When distillate was burned, a change from 200 to 100 F in the jacket water temperature increased the specific fuel consumption only 6.6 per cent when the engine was developing 14.5 hp; but when the engine was developing 3.6 hp, the same change in jacket water temperature increased the specific fuel consumption 12 per cent. The greater fuel consumption at low loads was probably due to lower manifold temperatures. When gasoline was burned with a 4.75 to 1 compression ratio, there was a considerable increase in the specific fuel consumption when the jacket temperature was changed from 200 to 100 F for all the different engine loads as shown in Table 2. When gasoline was burned with 5.90 to 1 compression ratio, a change in jacket temperature seemed to have a greater effect on the specific fuel consumption as the load on the engine decreased. At maximum load changing the jacket water temperature had practically no effect on the specific fuel consumption, but when the load was decreased to about 6 hp, the specific fuel consumption was increased *(Continued on page 389)*

TABLE 2. THE EFFECT OF CHANGING THE JACKET WATER TEMPERATURE FROM 200 TO 100 F ON SPECIFIC FUEL CONSUMPTION AT VARIOUS LOADS

Fuel	Distillate					Gasoline							
Compression ratio	4.75 to 1					4.75 to 1					5.90 to 1		
Horsepower	18	14.5	11	7.2	3.6	25	18	10.75	4.8	26	18	12	6
Lb fuel per hp-hr — 200 F	.830	.838	1.014	1.335	2.138	.639	.802	1.157	2.144	.596	.751	.956	1.619
Lb fuel per hp-hr — 100 F	.887	.893	1.078	1.392	2.397	.673	.855	1.252	2.247	.616	.801	1.048	1.778
Per cent increase in specific fuel consumption	5.6	6.6	6.3	4.3	12.1	5.3	6.6	8.2	4.8	0*	6.6	9.6	10.0

*The maximum horsepower with 5.90 to 1 compression ratio was not the same with the jacket water temperature at 200 F as it was at 100 F.

A Method for Determining the Velocity of Runoff Water

By A. W. Cooper and J. H. Neal
JUNIOR MEMBER A.S.A.E. MEMBER A.S.A.E.

SOIL erosion is caused by two primary factors—dispersion of the soil by the impact of the falling raindrops and overland flow of runoff water. The effects of these factors on soil erosion are being studied cooperatively by the Alabama Agricultural Experiment Station and the U. S. Soil Conservation Service. A preliminary report on the effects of the first factor has been presented by Laws[4]*. The specific objective of this project was to study the effect of rainfall intensity and land slope on the velocity and erosive power of runoff water.

The velocity of water flowing over soil and its erosive power govern the distance between terraces. Therefore, if the velocity of the water and the amount of soil the water moves at various velocities could be determined for varying degrees and lengths of slope, rainfall intensities, surface conditions, and vegetative covers, it would aid greatly in establishing a scientific basis for terrace spacing. An understanding of the laws of overland flow should also point to a better method of erosion control by vegetation.

The present terrace spacing recommendations have been based largely on a trial and error process. While there have been a great many plot experiments during the past 40 years in which runoff and soil losses have been determined, most of the spacing recommendations have been derived from field observations. Realizing the need for a scientific basis for these recommendations, R. E. Yoder** while connected with the Alabama station designed two large tilting plots to study some of the factors affecting terrace spacing and started the work on the measurement of increment velocities. Funds for constructing these tilting plots were provided by the Tennessee Valley Authority. The results and the limitations of the stationary erosion plots described by Diseker and Yoder[2] were given consideration when these tilting plots were designed.

The method and equipment used for determining velocity and some of the preliminary results on velocity of overland flow are reported in this paper.

Experimental Facilities. The field equipment used in this study consisted of two large tilting plots. Each plot was 15 ft wide and 50 ft long and consisted of structural steel framework which carried a watertight sheet metal soil bin 12 in deep. Each unit was mounted on four heavy bearings placed on concrete supporting piers and pivoted at the center.

A cable and drum mechanism facilitated the tilting of the plots to any desired slope up to 30 per cent. The tilting mechanism could not be used for the final accurate setting since there was a slight sagging at the ends of the plots. The final adjustment of the plots was accomplished by screw jacks set under each corner. Radial graduations on the side of the soil bin with a swinging plumb bob supported at the center of the arc were placed at each corner near the screw jack to enable the operator to set the plot at the desired slope. The soil bins were equipped with an adjustable front plate which could be lowered to the soil level as the surface was eroded. In the tests made to date Decatur clay loam, the predominant Tennessee Valley soil, was used.

The soil surface for the smooth fallow test was prepared by first wetting the soil to a workable moisture content and raking to break up clods and remove major depressions. Then a 2x4-in board templet with a carpenter's level on top was used to smooth and level the surface.

Artificial Rainfall Apparatus. The artificial rainfall apparatus first used consisted of two overhead 3/4-in wrought iron irrigation pipes equipped with "catfish" nozzles spaced 12 in apart. Water for this apparatus was supplied directly from the city water system. The amount of water was controlled by a valve and recorded in cubic feet with a meter. This apparatus was unsatisfactory for two reasons: (1) The pressure of the city water main varied and made it impossible to apply a rain of uniform intensity, (2) the nozzles made a fan-shaped misty spray of small drops which were easily blown away by the wind and did not give a uniform distribution over the plots.

The type F artificial rainfall apparatus† developed by the Soil Conservation Service was used in the later tests. It was employed with the help of D. A. Parsons and J. O. Laws, SCS hydraulic engineers, who are cooperating with the Alabama station. The type F equipment gave a larger size of drop and a more uniform distribution over the plot surface. The pressure was kept constant in the pipe by two centrifugal pumps which pumped the water from a large tank. A uniform rate of rainfall was applied by keeping the pressure constant at 35 lb per sq in. The type F nozzles were spaced 2 1/2 ft apart, 21 in horizontally, and 24 in vertically from the boundary on both sides of the plot. They were equipped with covers to allow adjusting of the pressure before the water was applied to the plot and also to vary the intensity of the rainfall by covering half the nozzles. This made it possible to use three intensities although two were about 1 3/4 in per hr. The third was approximately 3 1/2 in per hr.

It was necessary to reduce the width of the plot from 15 to 6 ft in order to use the type F rainfall apparatus. It was also shortened to 47 1/2 ft to allow space for a walk at the upper end of the plot. Sheet metal strips were bolted on 1x4-in boards and driven into the soil for the plot boundaries.

The first canvas wind barriers surrounded both plots and were away from the edges some distance allowing movement of air on the inside. The second canvas barriers were supported by a wooden framework over each plot. The canvas covered the top as well as the four sides and allowed no appreciable air movement on the inside of the cover.

The soil and water lost from the plot were collected and measured in two calibrated tilting tanks mounted on

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*Superscript numbers indicate the references appended to this paper.

**Former acting head, agricultural engineering department, Alabama Polytechnic Institute, and now head, agronomy division, Ohio Agricultural Experiment Station.

†Detailed plans of the type F rainfall apparatus may be obtained upon application to the U. S. Soil Conservation Service.

scales, as described by Bailey[1]. These tanks were made of 22-gage sheet metal with welded angle iron supporting frames to prevent bulging or sagging. They had a water capacity of 12 cu ft, and were attached to 1000-lb capacity scales. The tanks were so arranged that weighing, emptying, and changing the flow from one tank to the other could be done by one man.

Calibration of Rainfall Apparatus††. The type F rainfall apparatus was calibrated for rainfall intensities each time a series of tests was run. The three rainfall intensities used were from set A nozzles, set B nozzles, and a combination of the two which was called set AB. The set A nozzles consisted of the odd nozzles on the left side of the plot and the even nozzles on the right side. The set B nozzles included the evens on the left and the odds on the right side. On any one slope, after the infiltration rate was approximately constant, runoff rates were determined for each of the three sets of nozzles. Then the rainfall intensities were calculated as follows:

Rainfall intensity for set A nozzles=
runoff rate of set AB – runoff rate of set B

Rainfall intensity for set B nozzles=
runoff rate of set AB – runoff rate of set A

Rainfall intensity for set AB=
rainfall intensity of set A + rainfall intensity of set B

The scale tanks used to measure the amount of runoff water were calibrated in place in the cistern using 5-gal increments of water measured by two meters connected in series so that their readings served as a check on each other. Each increment of water was weighed and measured with a point gage, affording two methods for obtaining the amount of water.

The amount of soil lost was determined by taking ½-gal samples at 1-min intervals. The suspended material in the samples was flocculated with aluminum sulphate and the clear liquid siphoned off. The soil and remaining water were then poured into a weighed beaker and the water was evaporated at an oven temperature of 110 C. The soil was then weighed and the pounds per cubic foot of runoff water were calculated.

Method of Determining Velocity. Two electrolytic methods were used in the development of the method for determining the velocity of sheet or overland flow of water. The first was a sampling method which consisted of catching samples at definite intervals and determining the conductivity in the laboratory. The second employed electrolytic cells on the plot in series with milliammeters. This method was developed to eliminate errors due to the variation in the time which elapsed after the solution had fallen over the end of the plot until it reached the sampling bottle.

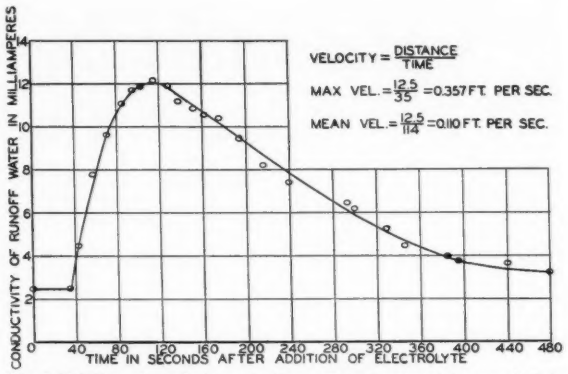
VELOCITY = DISTANCE / TIME
MAX VEL. = 12.5/35 = 0.357 FT. PER SEC.
MEAN VEL. = 12.5/114 = 0.110 FT. PER SEC.
CONDUCTIVITY OF RUNOFF WATER IN MILLIAMPERES
TIME IN SECONDS AFTER ADDITION OF ELECTROLYTE

Fig. 1 Relation of conductance to time. Slope increment traversed, 0 to 12½ ft. Test No. 1, 20 per cent slope, smooth fallow soil

After constant precipitation and runoff were reached, a stream of electrolyte (NaCl) was dumped at the top of the plot from a sheet metal trough divided into small sections to distribute the solution uniformly across the plot. Groups of eleven copper electrode cells arranged in three separate circuits, were placed at 5-ft intervals down the slope, except for the first group which was set 2½ ft from the top of the plot. Each of the three separate circuits of cells, which were connected in parallel, were connected in series with a potentiometer and a milliammeter. The current from a 110-v alternating-current line was rectified supplying a 6-v direct current to the circuit. When the electrolyte solution from the sheet metal trough hit the surface of the runoff water, a stop watch was started. When the solution reached each group of cells, it deflected the needles of the milliammeters which were mounted on the instrument board. At the start and throughout the swing of the needles pictures were taken of the 30 milliammeters and the stop watch with a 35 mm camera mounted on a rigid stand above the instrument board. Thus a record of the time taken for the solution to travel from the trough to each group of cells was obtained. From these readings of the milliammeters and the stop watch, which were recorded on the film, the so-called maximum and mean velocities were determined. The maximum velocity was calculated from the time it took the first of the solution to travel a set distance. The mean velocity was calculated from the time it took the peak concentration to travel the same specified distance.

Velocity of Runoff Water. Fig. 1 shows a typical relationship between the meter readings or conductance of the

††This method for calibration of rainfall apparatus was developed by D. A. Parsons of the Soil Conservation Service.

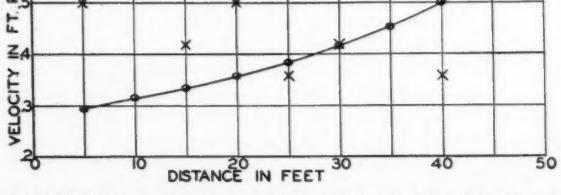

Fig. 2 Relation of maximum velocity to length of slope. Decatur clay loam, smooth fallow soil. o, Test 1, 20 per cent slope. x, Test 9, 20 per cent slope

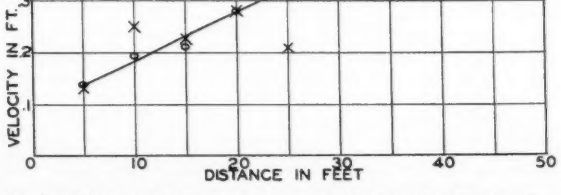

Fig. 3 Relation of mean velocity to length of slope. Decatur clay loam, smooth fallow soil. o, Test 1, 20 per cent slope. x, Test 9, 20 per cent slope

water and the time of travel on a 20 per cent slope. The curves for the other slopes were of the same general type. The meter readings were plotted along the Y axis and the time along the X axis. This particular chart shows the average conductance of the water as it passes under the group of electrodes 12½ ft from the top of the plot. In this case the first solution reached a point 12½ ft from the top of the plot in 35 sec. Therefore, the maximum velocity was considered to be 12½ ÷ 35, or 0.357 fps. The time required for the curve to reach a peak or for maximum concentration to be attained was 114 sec. Therefore, the mean velocity is assumed to be 12½ ÷ 114, or 0.110 fps.

King[3], describing the method of measuring the velocity of water in pipes by the use of a salt solution, called mean velocity the average between the time of application of the solution and the beginning and end of the milliammeter needle deflection. There is a difference, however, in the flow of water in a pipe and on a soil surface. The conductivity curve from the pipe studies would probably come down nearly as rapidly as it went up, while the conductivity curve used in this experiment, as shown by Fig. 1, tends to flatten out as the needle returns to the original position.

TABLE 1. VELOCITIES OF FLOW OF WATER IN FEET PER SECOND OVER SMOOTH FALLOW SOIL

DECATUR CLAY LOAM

Feet from top of plot	Test 1 - 20% slope		Test 9 - 20% slope		Test 5 - 2½% slope	
	Max. vel.	Mean vel.	Max. vel.	Mean vel.	Max. vel.	Mean vel.
2½- 7½	.294	.147	.500	.132	.178	.086
7½-12½	.312	.192	.625	.250	.312	.114
12½-17½	.333	.208	.416	.227	.192	.250
17½-22½	.357	.278	.500	.278	.138	.125
22½-27½	.384	.312	.357	.208	.227	.147
27½-32½	.417	.357	.416	.357	.250	.208
32½-37½	.455	.417	.625	.357	.250	.086
37½-42½	.500	.417	.357	.417	.312	.250
42½-47½	.556	.417	.625	.357	.357	.250

Discussion of Results. Table 1 contains typical data on velocity of flow of water over Decatur clay loam. The relationship of maximum velocity to length of slope is shown in Fig. 2. The circles represent the first velocity measurements made on the 20 per cent slope after a rainfall of 30 min duration was applied at a rate of 1.77 in per hr. At this time few rills had formed and the velocity increased fairly uniformly with length of slope. The crosses represent velocity measurements made on the same slope after a rainfall application of approximately 4½ hr. During the fifth 30-min period the rate of application was 3.52 in per hr, while for the remainder of the time the rate of application was 1.76 in per hr. The plot had rilled considerably by this time and the data show that the velocity of flow of the water was erratic. For example, the water was flowing faster at 10 ft than at 30 ft from the top of the plot. This condition was due to rills which were formed in the soil surface. On this particular soil type short rills form which concentrate the water making it flow rapidly; then the water gradually spreads and the velocity is reduced.

Fig. 3 shows the relationship of the mean velocity to the distance the water has traveled over a 20 per cent slope.

Figs. 4 and 5 show the relationship of maximum and mean velocities, respectively, to length of a 2½ per cent slope. The curves follow the same general trends as for the 20 per cent slope. These data were obtained after a rainfall application of approximately 2 hr at a rate of 1.77 in per hr. It shows that considerable rilling had taken place but not as much as in Test 9 on the 20 per cent slope.

TABLE 2. AVERAGE VELOCITIES OF FLOW IN FEET PER SECOND BETWEEN 2½ AND 47½ FEET FROM TOP OF PLOT

Slope, %	Rainfall intensity	Maximum vel.	Mean vel.	Ratio: mean vel./max. vel
20	1.76	.418	.259	.62
10	1.76	.389	.244	.63
2½	1.76	.227	.154	.68
2½	3.52	.312	.208	.67

Table 2 shows the maximum and mean velocities for the slope increment 2½ ft to 47½ ft from the top of the plot. Fig. 6 shows how velocity of flow of water increases with degree of slope under the same rainfall intensity. It can also be seen in Table 2 that by doubling the rainfall intensity the velocity of flow of the runoff water was increased approximately 35 per cent. Table 2 also shows that the ratio of mean velocity to maximum velocity is approximately 0.65.

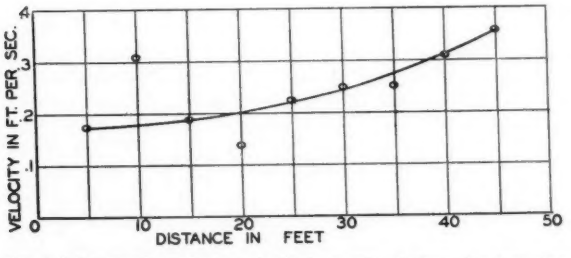

Fig. 4 Relation of maximum velocity to length of slope. Decatur clay loam, smooth fallow soil. Test 6, 2½ per cent slope

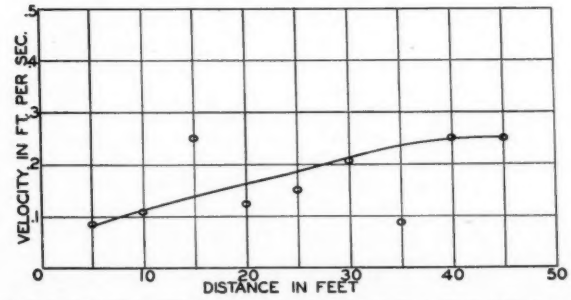

Fig. 5 Relation of mean velocity to length of slope. Decatur clay loam, smooth fallow soil. Test 6, 2½ per cent slope

SUMMARY AND CONCLUSIONS

This paper is a report of the method of procedure and some preliminary results of the determination of velocity of overland flow.

The field equipment used consisted of two large tilting plots 50 ft long and 15 ft wide. Each plot carried a watertight sheet metal bin 12 in deep which was filled with 10 in of Decatur clay loam *(Continued on page 389)*

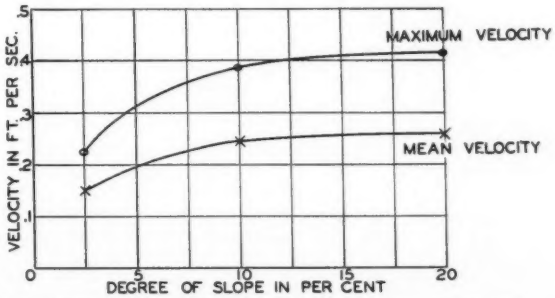

Fig. 6 Relation of velocity to degree of slope. Decatur clay loam

Effect of Production Costs on Returns from Sugar Beets

By W. L. Ruden and G. H. Lambrecht

THE AVERAGE cost of producing sugar beets in the irrigated sections of western Nebraska in 1941 varied from $4.26 to $9.81 per ton. This wide variation was the result of differences in quality of land, crop and soil management, and labor efficiency. The latter factor had more effect on costs than either land grade or cultural practices (Table 1). While all of the land in beets may not have been best adapted for that crop, there was none of exceptionally poor quality.

Representatives of the department of rural economics, University of Nebraska, obtained cost records from beet growers in Scotts Bluff, Sioux, and Morrill Counties. The farmers reported the time required to perform various operations and the cost of materials needed to produce sugar beets in 1941. Data on the cost of operating machinery were secured and these rates were used in computing total costs. A detailed description of all costs and computations is given in Nebraska Agricultural Experiment Station Bulletin 341, entitled "Sugar Beet Costs and Management in Western Nebraska."

TABLE 1. INFLUENCE OF MANAGEMENT AND GRADE OF LAND UPON THE COST OF PRODUCING SUGAR BEETS

Management		Quality of land					
		I		II		III and IV	
Crop and soil*	Cost per acre prior to harvest,** dollars	Number of records	Cost per ton***	Number of records	Cost per ton***	Number of records	Cost per ton***
Good	25–39	18	$4.26	6	$4.40	1	$4.67
	40–54	64	5.03	30	5.51	18	5.35
	55–69	19	5.97	12	6.16	9	6.49
Fair	25–39	4	4.40	5	4.45	3	4.75
	40–54	11	5.39	6	5.57	12	5.91
	55–69	3	6.25	6	6.67	5	8.32
Poor	25–39	2	5.92	4	6.03	9	5.28
	40–54	8	5.93	8	6.24	10	7.43
	55–69	3	6.39	3	7.72	7	9.81

*The factors included under crop and soil management practices emphasize the importance of using good cultural methods in obtaining large yields. They are listed in the sixth paragraph of this article.

**Growers who produce beets on a given grade of land at low cost are better managers than those who produce beets on the same grade of land at high cost.

***Cost per ton includes a land charge based upon the customary share rent for the crop which was one-fourth of the beets.

Labor efficiency, as measured by hours of labor required per acre prior to harvest, varied greatly for different growers. Some beet producers tilled the soil much more intensively than others. There was also a great variation in the speed of doing certain jobs. The least efficient groups required around 50 per cent more time for seedbed preparation and approximately double the time for cultivating and irrigating than the men who kept their costs between $25 and $39 per acre. Most of the differences in time requirements for cultivating and irrigating were due to the rate of doing the work rather than to the number of operations. There was sufficient labor expended on all fields to keep them reasonably free from weeds.

Labor requirements prior to harvest had practically no effect on beet yields, but crop and soil management was the most important factor and the quality of land as classified had a highly significant influence upon yields. The relative importance of the causes of differences in yields was summarized by an analysis of variance (Table 2).

Labor requirements vary with soil and topography and may not be entirely within the control of the operator. Whenever jobs can be speeded up or eliminated without affecting yield, the cost per ton of producing beets can be reduced. Data in Table 2 show that the amount of time spent on the beets up to harvest had little relationship to yields.

TABLE 2. YIELDS OF SUGAR BEETS IN RELATION TO QUALITY OF LAND, CROP AND SOIL MANAGEMENT, AND HOURS OF MAN LABOR PRIOR TO HARVEST IN WESTERN NEBRASKA, 1941*

Management of crop and soil	Hours of labor prior to harvest**	Quality of land					
		I		II		III and IV	
		Number of records	Tons per acre	Number of records	Tons per acre	Number of records	Tons per acre
Good	10–29	34	20	13	18	6	18
	30–49	58	19	25	18	15	17
	50–69	8	20	10	17	7	16
Fair	10–29	9	18	7	18	8	16
	30–49	7	17	9	14	9	15
	50–69	2	19	1	18	3	14
Poor	10–29	4	12	4	12	7	14
	30–49	8	16	9	14	9	13
	50–69	1	18	1	17	8	12

*An analysis of variance showed the following F values:

Hours of labor prior to harvest	1.3
Quality of land	10.7
Management of crop and soil	23.1
F at 1% point for d.f. 2 and 255 is	4.70

**Labor for blocking, thinning, and hoeing is not included.

The factors used in determining the quality of crop and soil management are as follows: (1) Maintenance of fertility, (2) control of wind erosion to prevent damage to beet seedings, (3) prevention of water erosion during irrigation, (4) crop management, including seedbed preparation, planting, cultivating, control of diseases and insects, supervision of beet workers, and irrigation.

The land classification was made on the basis of productivity and topography. Each 40-acre tract in the Gering-Ft. Laramie and Pathfinder Irrigation Districts has been classified by their representatives. Approximately two-thirds of the sugar beet records were taken on land located in those districts. The land in beets on the remaining farms where cost records were collected was classified on the basis of data from a soil survey map and observations of topography and soil fertility by the enumerator. Land quality I is the best irrigable land, II is the next grade, and Grades III and IV consist of land that is less desirable for irrigation purposes. This classification could be improved by being made on a field basis rather than in 40-acre tracts within the irrigation districts and by the use of an up-to-date soil survey map if it were available. Not all the land in the 40-acre tracts was of uniform quality. The classification represents the dominant type but some parts of many of the tracts had land of higher or lower grade than as classified.

The cost of man labor for blocking, thinning, and hoeing amounted to 19 per cent of the cost of producing

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beets up to harvest. Hand work is required because of the characteristics of the seed. Sugar beet seeds are seed balls which enclose one to five or more true seeds. The drills or planters used by most farmers scatter the seed balls in groups and the seedlings come up in clumps. These seedlings must be thinned leaving one plant at regular intervals in the row. Additional hand work is required to destroy the weeds that are not killed by cultivation.

Recent technical developments will make it possible to use machines to replace a large part of the man labor. A method of breaking the seed balls into segments, each segment producing one or two seedlings, has been developed recently. Most of the sprouts from segmented seed are single plants. Cross blocking can be done mechanically, and thinning can be done with long-handled hoes. Mechanical topping and harvesting equipment developed at the University of California promises to replace a considerable part of the hand labor at harvest.

Minimum wages for sugar beet labor are fixed by geographical districts after hearings are held by representatives of the Secretary of Agriculture. These wage rates are established on a per acre or ton basis. Under these conditions the farmer's management problem with respect to blocking and thinning is confined to obtaining work of satisfactory character. If this phase of sugar beet production becomes mechanized, the farmer will have the additional problem of using labor and machines efficiently so that costs will not be excessive. The information obtained through this survey indicates that some farmers were not obtaining efficient use of labor and other resources in 1941. Complete mechanization of sugar beet production may not help those growers to reduce costs.

The Effect of the Jacket Water Temperature on Crankcase Dilution and Fuel Economy of a Tractor Engine

(Continued from page 384)

10 per cent when the jacket water temperature was decreased from 200 to 100 F.

After measuring the effect of the jacket water temperature on fuel consumption, it seemed desirable to compare the specific fuel consumption and the fuel cost when distillate was burned and when gasoline was burned with both the high and low compression heads. Fig. 3 shows that the specific fuel consumption is greatest for this engine when gasoline is burned with 4.75 to 1 compression ratio and least when distillate is burned. In this case the compression ratio was relatively high for the distillate used, and the high compression was comparatively low for 73 octane gasoline, resulting in efficiencies in favor of the distillate. At 18 hp the specific fuel consumption for distillate is greater than for gasoline because of detonation.

Fig. 4 shows the relative fuel consumption on a volume basis. Since the specific gravity of distillate is higher than that of gasoline, the fuel consumption on a volume basis gives a still greater advantage to distillate; and since fuel is purchased by volume and not by weight, this comparison should be of special interest to the tractor operator.

The fuel prices used in plotting curves in Fig. 5 were retail prices for the fuels in Minneapolis, Minnesota, on August 1, 1941. When the price per gallon is slightly over half as much for distillate as for gasoline, with proper heat control the fuel cost per unit of work is significantly in favor of low grade fuel.

Baling Straw Left by Combine

(Continued from page 378)

No attempt has been made to calculate the cost of operating the combine. It is thought that it should not vary greatly for the three tests; in fact, there is no reason why Tests A and B should differ. The cost per acre should be slightly less for Test C than the other two because of the higher rate of travel and increased acres per hour harvested. It is doubtful if the saving in cost of combining when cutting the grain high as compared with cutting low would greatly offset the increase in cost of saving the straw. Certainly combining with a high stubble could not be justified when, as here, the total grain losses were more than when cutting low.

A Method for Determining the Velocity of Runoff Water

(Continued from page 387)

soil. A cable and drum mechanism facilitated the tilting of the plots to any desired slope up to 30 per cent. The plots were equipped with the type F artificial rainfall apparatus.

An electrolytic method was used to determine the increment velocities of overland flow down the plot slope. Electrolytic cells, which were placed at 5-ft intervals down the slope, were connected in series with milliammeters. Salt (NaCl) was introduced at the top of the plot from a sheet metal trough. As the salt touched the surface of the runoff water a stop watch was started, and as the salt reached the set of cells the needles of the milliammeters were deflected. Pictures were taken of the milliammeters and the stop watch to record the readings. The time at which the first deflection of the milliammeter occurred was used to calculate the maximum velocity and the time at which the maximum deflection occurred was used to calculate the mean velocity.

Although enough data have not been obtained to draw definite conclusions, these results have been presented to show probable trends. In general, velocity of sheet or overland flow of water increased with degree and with length of slope. However, after rills had formed in the Decatur clay loam, the velocity of flow became erratic and increased or decreased, depending on whether the water was flowing in rills or had spread out.

As yet no attempt has been made to correlate velocity of flow of the runoff water with the soil losses. This was not done for these tests because the soil losses decreased with length of rainfall application. Tests on all slopes were run consecutively without stopping the rainfall.

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AUTHOR'S NOTE: The authors are indebted to R. E. Yoder for his initial plan in carrying out the research project. He designed the tilting plots and made the preliminary tests to determine increment velocities. Although the procedure was changed, the principal objective remained as he worked it out.

Germicidal Lamps for Treatment of Air

IN ORDER to evaluate the effectiveness of the bactericidal treatment of air there is coming into general acceptance the concept of sanitary ventilation in which the rate of disposal of bacteria is expressed in terms of the equivalent number of displacements per hour of room air by fresh air needed to secure a given disposal of bacteria. For example, tests have shown that a single 15-w germicidal lamp made of No. 974 glass installed in the center of a room of 4000 cu ft volume in such a way as to irradiate only the upper half of the room will produce in the entire room a sanitary ventilation equivalent to 100 changes of air per hour, as against five changes per hour, the usual under average indoor winter ventilation and only about 15 to 20 with the best air conditioning systems.

Germicidal lamps are now in operation in various schools and hospitals and remarkable results have been obtained by their use in preventing the spread of contagious diseases. For example, during a measles epidemic in Philadelphia only 12 to 14 per cent of the children in schools equipped with germicidal lamps contracted the disease as against 60 to 70 per cent in similar schools in the same locality but having no germicidal lamps.

In an eastern hospital children's ward during 6 months, out of 150 children protected with germicidal lamps there were only four with infections while during the same period there were 28 out of a similar group of 224 children without germicidal lamps.

The two principal sources of germicidal radiation are the hot cathode type germicidal lamp as made by General Electric Company and the cold cathode type sterilamp as made by the Westinghouse Company. A list of references to published articles pertaining to the use of these lamps is appended. (A list of manufacturers making equipment using the lamps will be furnished on request to AGRICULTURAL ENGINEERING.)

Of direct interest to the agricultural field is a piece of research recently completed by Harry Stierli and F. R. Smith in the college of agriculture at the University of California at Davis. It pertains to the use of germicidal lamps on meat and cheese during storage. Various cuts were stored with and without ultraviolet, then cooked and tested for flavor, tenderness, odor, etc. In most cases practically no differences were found. In a few, however, the untreated meat had molded or spoiled before cooking to a considerably greater extent than the treated meat. The conclusions reached read as follows:

"1 Ultraviolet light inhibits the growth of certain molds and bacteria that occur on meat in storage.

"2 Anything that casts a shadow is an effective screen against ultraviolet light.

"3 Certain substances generally considered as transparent effectively filter out ultraviolet light. Mineral oil films, waxes, and ordinary glass are included in these filtering substances.

"4 Because of the necessity of covering cheese with paraffin or some similar substance, we could get no favorable method for this treatment.

"*Control of Mold in Condenser Water* (Supplementing last year's report—Agr. Engrg., Dec. 1941, p. 439). A 15-w germicidal lamp has been in use in the evaporative condenser with favorable results. The lamp is so placed that the surface of the water in the tank and the drip off the coils is continuously irradiated. During the cold weather they have very little trouble with or without the light, but during the warm summer months, if the lamp is not used, the mold develops after the second or third day. If the light is used, no growth develops. It is estimated that the lamp saves 100 man-hours per year."

Also at the University of California, Hayden Gordon reports experiments on the use of 250-w reflector-bulb drying lamps for drying fruit and herbs. Different varieties of peaches, prunes, and pears were used. Thermocouples were inserted in the fruit to measure temperatures at various depths and hourly readings were taken. The fruit was dried whole and also halved, and was turned from time to time while under the lamp. Observations were made of the appearance of the fruit in comparison with fruit dried naturally. In general, temperatures in the fruit under the lamp were of the order of 160 to 200 F and drying took about 27 hr for prunes and peaches and about 40 hr for pears.

Fresh sage leaves were dried in about 4 hr using a fan and the lamp. A rotary kiln type dryer using six of the 250-w drying lamps was very successful.

No cost evaluation was made of this method of drying in comparison with other methods.

In general, the use of drying lamps for dehydration purposes is a little more expensive than the use of other sources of heat, but the convenience of the lamps may more than offset their possibly higher cost.

During the past year additional research was conducted at the Ohio Agricultural Experiment Station on the use of various types of lamps to reduce insect infestation of outdoor areas at night. The full report was published in AGRICULTURAL ENGINEERING for February 1942 (vol. 23, no. 2). As a result of the last two years' work we draw the following conclusions:

1 The closer light approaches the blue end of the spectrum, the more insects it attracts.

2 The closer light approaches the red end of the spectrum, the fewer insects it attracts.

3 Brightness of the light source is a very dominant factor; the higher the brightness the greater its attraction power.

4 The substitution of yellow lamps for white lamps of equal candlepower reduces the number of insects attracted by approximately 50 per cent, but the use of yellow lamps will by no means free an area from insects to the point of comfort.

5 The use of bare lamps of any color is about the worst method of lighting that could possibly be used from the standpoint of attracting the least number of insects, first, because bare lamps attract insects from all directions, and, secondly, because only a small percentage of the total light emitted falls on the area it is desired to light.

6 The use of reflectors on regular inside-frosted lamps will make a much greater reduction in the number of insects than substitution of any color for white.

7 The use of projector or reflector spotlight type bulbs results in the maximum reduction of insects when the sources are located twenty or more feet away from the area it is desired to protect.

8 The addition of opal diffusing globes or other means of reducing brightness of bare lamps will reduce the num-

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A contribution of the A.S.A.E. Committee on Electric Light in Insect and Bacteria Control, filed June 29, 1942—L. C. Porter (chairman), B. D. Moses, H. C. Rentschler.

bers of insects attracted but at the expense of lower levels of illumination, and therefore is a less efficient and more costly method than the use of reflectors or projector and reflector type lamps. When the latter are used several lamps should be used at different locations to reduce deep shadows that result when light comes all from one direction.

Additional research along the same lines was conducted by Prof. H. M. Weiss of the Bureau of Plant Industry (USDA) at Trenton, New Jersey. The principal difference between this and the Wooster research was that at Trenton the work was done in the laboratory and mostly with day-flying insects. A summary of the work indicates that 29 species of day-flying insects were exposed to 8 to 10 colors between 3650 and 7400 (near ultraviolet to deep red) all at equal intensities.

At high intensities most insects were attracted in the blue-green range, while at low intensities the greatest attraction was in the near ultraviolet to blue range.

There was very little attraction in the yellow to red range.

In the case of Japanese beetles high intensity red proved more attractive than low intensity blue.

At medium intensities Japanese beetles and potato beetles were found to respond to all colors but not to infrared.

Prof. Weiss concludes that of the two factors, wavelength and intensity of light, the latter is by far the most important.

While the Weiss tests were made with day-flying insects and the Wooster tests with night-flying insects, in general the conclusions reached are quite in agreement, namely, that most insects are attracted by the blue end of the spectrum and least by the red end; that brightness or intensity is a very potent factor. Weiss does indicate a shift toward the near ultraviolet in relative attractiveness when the intensity or brightness is lowered in a range of 100 to 3.

The complete report of the Weiss tests is published in the Journal of the New York Entomological Society, vol. L, March 1942, pages 1-35.

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NEWS

A.S.A.E. Meetings Calendar

Feb. 5 and 6—Pacific Coast Section Meeting, Logan, Utah.

June 21 to 23—Annual Meeting, Purdue University, Lafayette, Ind.

Southeast Section Meeting Probable

IN RECENT years the Southeast Section of the American Society of Agricultural Engineers has held its yearly meeting in connection with the annual convention of the Association of Southern Agricultural Workers. However, the A.S.A.W. convention scheduled for February 1943 has been cancelled, but the officers of the A.S.A.E. Southeast Section are convinced that the agricultural engineering group should hold its meeting just the same and has proposed that a section meeting be held at Atlanta, Georgia, the first week in February 1943. The matter is now being presented to the Section membership at large, but it is anticipated that there will be general approval for the meeting.

Section Chairman Walter N. Danner proposes that the program for the meeting be built around the theme "Food Front for a Nation in War," and also that the horticultural section of the A.S.A.W. be invited to participate in a joint program with the Southeast Section for at least a one-day program devoted to the dehydration of the sweet potato for livestock feed and to the results of research work on fruit and vegetable dehydration now under way in the Southeast.

Other subjects of particular import to agricultural engineers in wartime are contemplated for the program now under consideration.

Personals of A.S.A.E. Members

J. M. Armstrong and *W. Kalbfleisch*, agricultural engineers of the Dominion Experimental Farms, Canada, are two of the authors of Farmer's Bulletin 111, entitled "Land Clearing," issued recently by the Canadian Department of Agriculture at Ottawa.

H. J. Barre, agent, Bureau of Agricultural Chemistry and Engineering, USDA, and research assistant professor in agricultural engineering, Iowa State College, is one of the authors of a comprehensive article, entitled "Recent Developments in the Farm Storage of Grain," which appeared in the October 24th issue of "Feedstuffs."

Harry F. Blaney, irrigation engineer, division of irrigation, Soil Conservation Service, USDA, is one of the authors of Bulletin No. 50, entitled "Use of Water by Native Vegetation," published by the Department of Public Works of California. The subject matter was prepared by the authors in cooperation with the division of water resources of the State of California, and is one of the most complete compilations of data dealing with the use of water by native vegetation that has been issued.

Orval C. French, a member of the agricultural engineering staff of the University of California, has obtained a leave of absence to serve with the staff of the engineering college of the University for the duration of the war, with duties at the radiation laboratory at Berkeley.

Thomas E. Long, assistant agricultural engineer, North Dakota Agricultural Experiment Station, is author of Circular No. 66, entitled "Temperature Studies in Various Types of Potato Storage Houses," issued by that station in October 1942.

S. H. McCrory is relinquishing, for the duration, his position as assistant chief of the Bureau of Agricultural Chemistry and Engineering, USDA, to take charge of the hemp division of the Commodity Credit Corporation, which has for its goal the production of 300,000 acres of American hemp and some 50,000 acres of seed hemp in 1943.

Earle K. Rambo, extension agricultural engineer, University of Arkansas, is one of the authors of a food-for-victory leaflet, entitled "Inexpensive Methods for Storing Fruits and Vegetables," recently issued by that institution. It is designated Extension Plan Series No. 3.

Lyman L. Roberts has, since August 15th, been head safety engineer for the Ordnance Department of the Army at the Wolf Creek Ordnance Plant, Milan, Tenn. He severed his connection with Allis-Chalmers Mfg. Co. in August 1941, and has been in explosives safety work since that time. *(Continued on page 394)*

A Critical Wartime Job for Engineers . . . WATER MANAGEMENT

As LABOR leaves the farm for military service or to enter war industries, the need grows steadily to speed farm work with less manpower—and to get the utmost productiveness from every acre of land available.

Water management helps a great deal.

Millions of acres of land will yield far bigger crops, with improved drainage and irrigation facilities.

Emergency ditching and draining brings real dividends even in pasture land. With proper conservation of pasturage—by efficient control of the water supply—you can graze stock for extra months. Less barn feeding and less labor is necessary.

For ditching, water control and water conservation, use Atlas explosives. They save time, labor and equipment . . . are economical and easy to handle.

Write today for the new Atlas book "Explosives in Agriculture, Lumbering, Forestry." It has just been issued and offers valuable information in making the most of today's facilities.

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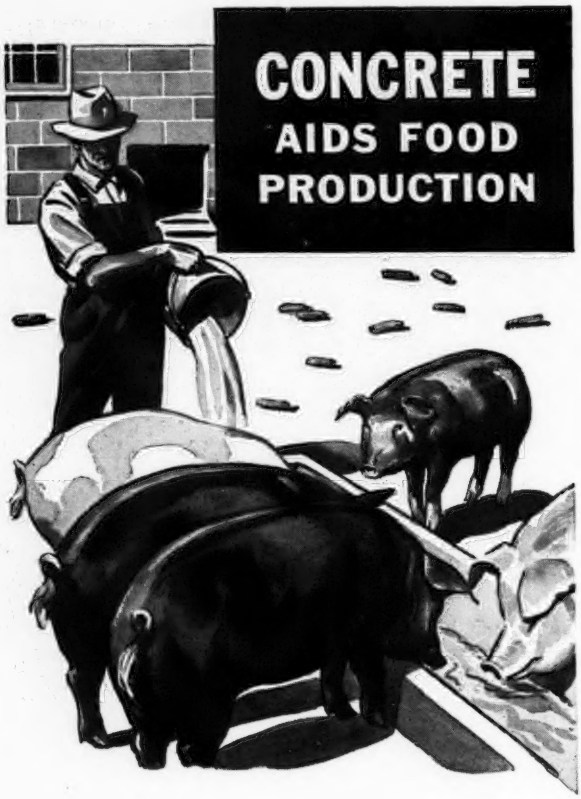


conserves scarce materials and transportation

In recognition of war needs, the Portland Cement Association has prepared modified designs for the principal concrete farm structures that aid food production or storage.

While concrete normally conserves materials, some of which are now scarce, these suggested designs *substantially reduce or eliminate reinforcing steel.* Concrete materials are usually available locally, requiring a minimum use of transportation.

Plan sketches and "how to build" data on these designs are being made available to farmers. Our engineers will be glad to consult with you on similar design problems.

PORTLAND CEMENT ASSOCIATION
Dept. 12-1, 33 W. Grand Ave., Chicago, Ill.

BUY WAR SAVINGS BONDS AND STAMPS

Personals of A.S.A.E. Members

(Continued from page 392)

H. P. Smith, chief, and *M. H. Byrom,* agricultural engineer, division of agricultural engineering, Texas Agricultural Experiment Station, are two of the authors of Bulletin No. 616, entitled "Germination of Cottonseed as Affected by Soil Disturbance and Machine Placement of Fertilizer," issued by that station in August 1942.

Archie A. Stone has, for the duration of the war, been granted a leave of absence from his duties as head of the department of rural engineering at the State Institute of Applied Agriculture on Long Island (New York) to serve as chief, farm equipment section, price division, Office of Price Administration, in Washington.

O. J. Trenary, assistant professor of agricultural engineering, State College of Washington, is one of the authors of a mimeograph bulletin issued in June of this year by the Washington Agricultural Experiment Station, entitled "Fumigation of Dry Peas for Weevils Including Plans for a Fumigation Chamber."

Richard L. Witz has accepted a position as extension assistant agricultural engineer at Michigan State College, having resigned as assistant in agricultural engineering at Purdue University.

Fred C. Yoder, Jr., is now connected with Westinghouse Electric & Manufacturing Co., at Canton, Ohio. His position is that of expediter in the purchasing department, to secure prompt delivery on orders placed with outside suppliers. Prior to taking this position he was connected with the J. I. Case Co.

F. D. Yung, research engineer in rural electrification, University of Nebraska, is one of the authors of Bulletin 344, entitled "Sunlight Lamps for Laying Hens," bearing the date of September 1942 and issued by that institution.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Victor C. Kallal, project superintendent, Southwestern Electric Cooperative, Inc. (Mail) 115 S. Second St., Greenville, Ill.

James E. Sexton, agricultural service manager, tractor div., Allis-Chalmers Mfg. Co. (Mail) 1031 S. 76th St., Milwaukee, Wis.

Harry C. Smith, service manager, Massey-Harris Co., Racine, Wis. (Mail) 1530 Arthur Ave.

James P. Sproul, assistant agricultural engineer, Soil Conservation Service, USDA. (Mail) P. O. Box 425, Troy, Kans.

C. J. Steinbrunner, service manager, New Idea, Inc., Coldwater, Ohio. (Mail) 500 E. Walnut St.

Byron C. Yarbrough, 101 DeBardeleben, Auburn, Ala.

Student Branch News

GEORGIA

By Dan Harrell, Scribe

A MEETING of all agricultural engineering students was called by Mr. R. H. Driftmier, head of the agricultural engineering department of the University of Georgia, at the beginning of the fall quarter for the purpose of welcoming and acquainting the new students with the department. The members of the faculty and president of the Georgia Student Branch of A.S.A.E. were presented.

The Branch president, D. L. Payne, in turn presented each Branch officer who gave a word of welcoming to the new students. The officers of the Branch for the fall quarter are: D. L. Payne, president; Warren Garner, vice-president; Charlie Robertson, secretary; Dan Harrell, scribe; Irby Exley, editor of the Georgia Ag Engineer; David Firor, business manager of the Ag Engineer and treasurer of the Branch, and Professor W. N. Danner, faculty advisor.

Our first regular Branch meeting was held October 12. The program consisted of an address by Paul W. Chapman, dean of our college of agriculture. He stressed the need of adjusting farm prices in comparison with other commodities and labor; also he visualized the agricultural trends after the war, emphasizing the importance of agricultural engineering. *(Continued on page 398)*

TO OUR FARM MACHINE CUSTOMERS

THE War Production Board on October 20 issued the 1943 Farm Equipment Limitation Order, fixing the amount of farm machinery which can be manufactured between November 1, 1942, and October 31, 1943. As this new order drastically affects the ability of the International Harvester Company to supply machines to its farmer customers, we feel that a brief statement is necessary in order that you may plan your future operations far enough in advance to safeguard the nation against any serious interruption in the Food-for-Freedom program.

New Machines Cut to ONE-FIFTH

The purpose of the 1943 Limitation Order is to limit the entire farm equipment industry to produce for American farmers during 1943 not more than 20 per cent, or one-fifth, of the amount of new equipment that was built in 1940.

The government has further adopted the policy of concentrating this limited production for 1943, insofar as possible, with smaller manufacturers. The 1943 Limitation Order therefore provides that preference shall be given to manufacturers on the basis of their size. A group consisting of the smallest manufacturers has the smallest cut in production, a second group of small to medium-size manufacturers comes next, and the larger companies have the largest cut in production.

The result is that the 1943 Limitation Order stops production completely on the great majority of farm machines heretofore manufactured by International Harvester. On a comparatively few machines we are permitted to continue production on a severely reduced basis. It means that our company's 1943 production will fall substantially below the 20 per cent of 1940 average for the whole industry. On a tonnage basis, our company's 1943 production of new machines will be only 14 per cent of 1940, and 12 per cent of the 1941 output. Other companies similarly classed as large manufacturers will be similarly affected.

All Equipment to Be Rationed

As you have been previously advised by the United States Department of Agriculture, this small amount of new equipment will be rationed to farmers, under a rationing system established by the Department of Agriculture.

The 1943 production program was adopted by the War Production Board, in cooperation with other governmental war agencies, as a part of its plan to curtail use of steel and other critical materials so as to increase the amounts available for the production of ships, planes, and weapons of war. Only the government could decide a question of such far-reaching importance.

Harvester's Wartime Pledge

Our company, of course, is keenly aware of the shortages of manpower and equipment with which farmers in many sections of the country are contending. Much has already been done by resourceful farmers and many patriotic groups to overcome these handicaps. Governmental agencies are undertaking to deal further with the problem. We are sure that the farmers of the nation will make every effort to produce the food required in 1943.

The International Harvester Company desires to state clearly that it will cooperate earnestly with the government's 1943 Limitation Order. We pledge anew to the farmers that we shall do our utmost, within these limitations, to help them with their equipment problems in 1943.

We can be of greatest help to our farmer customers in every community by continuing to supply them with repair parts and services for the McCormick-Deering equipment on which they have relied for so many years. The 1943 Limitation Order permits production of substantially the same volume of repair parts as produced in 1942. Harvester will continue to produce repair parts up to the limitations of the order and available materials, and will do everything in its power to help the McCormick-Deering dealers maintain the best service facilities possible under wartime conditions.

Put New Life in Your Old Machines!

The owners of McCormick-Deering machines can perform a patriotic service by ordering needed parts and arranging for service to keep their existing equipment in use for the longest possible time, thereby saving steel and other materials for war manufacture. McCormick-Deering dealers will make every effort, within the restrictions imposed on them, to carry adequate stocks of repair parts and maintain service men for that purpose. This should make it possible for our customers to continue using the machines with whose design, performance, and quality they are familiar, and to maintain their farm production at the highest possible levels under the circumstances.

For your country and your peace of mind, check over your machines and tools. *Make sure that you order all parts and service work in time for the job ahead!*

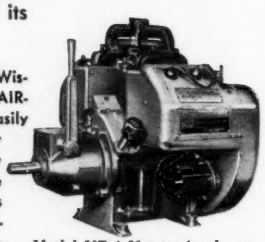
INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue **Chicago, Illinois**

INTERNATIONAL HARVESTER

NO Winter FREEZE-UPS

Even though duly delegated manpower may have instructions to provide against power equipment damage or slowdowns resulting from cold weather . . . the human equation can't always be depended upon to make good on its responsibilities.

There is nothing to freeze in a Wisconsin heavy-duty air-cooled engine. AIR-COOLING, and the ability to start easily in any weather . . . to run *continuously* under a full working load, on any kind of job within its power range . . . these are factors that logically make Wisconsin Engines the preferred year-round power.



Model VE-4 V-type 4 cyl. engine. Other types and sizes, 1 and 4 cyl. 1 to 35 hp.

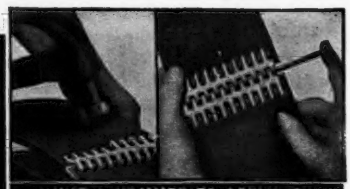
MOST POWER Per POUND

WISCONSIN MOTOR Corporation

MILWAUKEE, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

BELT LACING and FASTENERS for transmission and conveyor belts



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STEEL BELT LACING

World famed in general service for strength and long life. A flexible steel-hinged joint, smooth on both sides. 12 sizes. Made in steel, "Monel Metal" and non-magnetic alloys. Long lengths supplied if needed. Bulletin A-60 gives complete details.

FLEXCO HD

BELT FASTENERS AND RIP PLATES

For conveyor and elevator belts of all thicknesses, makes a tight butt joint of great strength and durability. Compresses belt ends between toothed cupped plates. Templates and FLEXCO Clips speed application. 6 sizes. Made in steel, "Monel Metal", non-magnetic and abrasion resisting alloys.

By using Flexco HD Rip Plates, damaged conveyor belting can be returned to satisfactory service. The extra length gives a long grip on edges of rip or patch. Flexco Tools and Rip Plate Tool are used. For complete information ask for Bulletin F-100.

Sold by supply houses everywhere

"CONVEYOR BELTS EASILY FASTENED"

FLEXIBLE STEEL LACING CO.

4677 Lexington St.
Chicago, Ill.

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the address indicated.

PRECOOLING AND DRYING OF WASHED IRISH POTATOES, *W. D. Poole and H. T. Barr.* Louisiana Ag. Exp. Sta. (University), Bul. 332 (1941). Washing was found to increase tendency to rot, and drying and cooling by means of bunker fans helped to prevent such decay. Other improvements helping to diminish these losses were the use of a potato digger in place of a middle breaker, resulting in less cutting and bruising, substitution of crates for sacks in hauling from the field, and replacement of the very inefficient precooling and drying practices of some shippers by better methods. An efficient bunker-fan unit for precooling and drying potatoes can be made at a relatively low cost. The mechanical refrigeration unit had a lower air delivery than the bunker-fan units, but the fans showed a more even temperature distribution throughout the car. A more thorough drying resulted when bunker-fan units were operated while the car was being loaded before icing the bunkers. Greater moisture loss was obtained from crates than from sacks during precooling by the bunker-fan method. It was found not advisable to have a potato temperature below 55 F when shipping under standard ventilation.

ELECTRICAL STERILIZING EQUIPMENT FOR FARM DAIRIES, *J. R. Tavernetti* and *K. F. McIntire.* California Ag. Exp. Sta. (Berkeley), Bul. 650 (1941). Electrically operated dairy-equipment sterilizers have proved practical, have certain advantages over other types, and are commonly used. The self-contained sterilizer, with the steam generator and sterilizing cabinet as one unit, is the most economical in both initial and operating costs, but does not supply controlled steam. For the self-contained sterilizer, the heating element with the automatic device for turning it off when not immersed is advised. To prevent the burning out of one element will more than offset the additional cost (about $15). The energy consumption of the various steam boilers available was found approximately the same. The accumulator boilers are less troublesome where hard water is used. A water softener should be put in with the instantaneous boilers when hard water is used. Advice concerning the setting up and operation of various types of sterilizer, size of cabinets with relation to number of cows, etc., is given, together with estimated power consumption and costs.

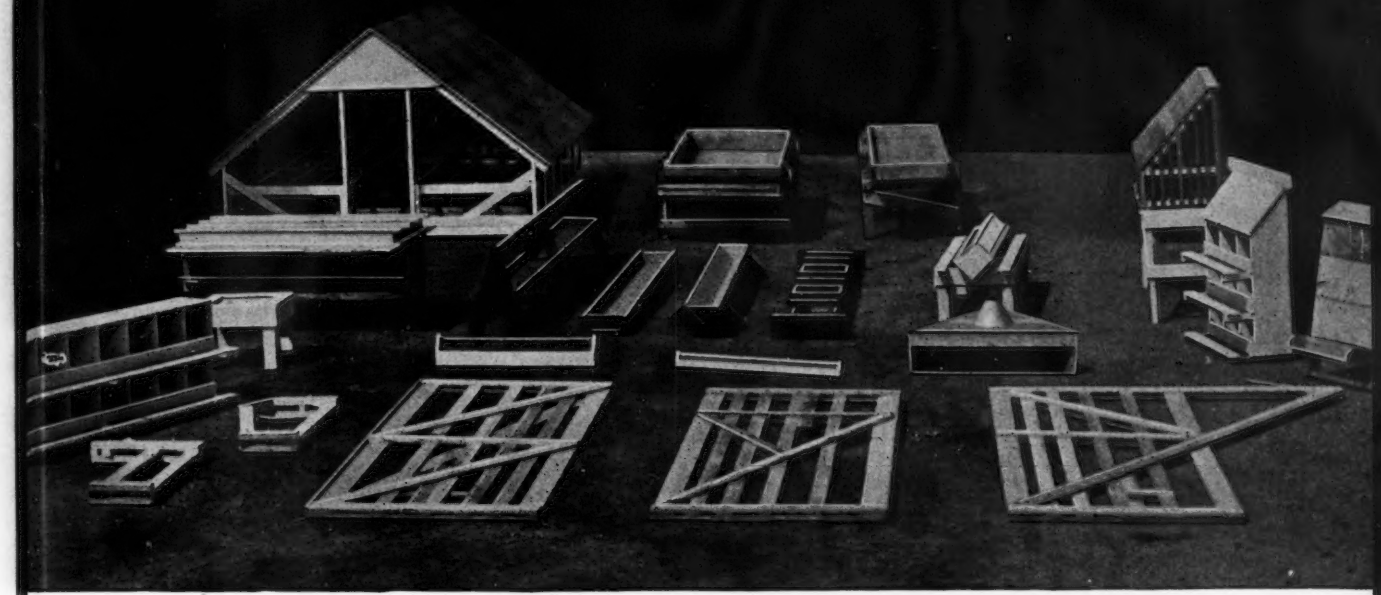
PRECAST TILE BEAM FLOOR, *H. Giese* and *C. T. Bridgman.* Iowa Ag. Exp. Sta. (Ames), Res. Bul. 286 (1941). This bulletin reports upon two series of tests, the first made with a beam tile as first conceived, and the second with a tile revised to eliminate the shortcomings of the first. In addition to the beam tests, several tests were made of slabs and completed floors to secure approval for construction purposes in several cities. From these tests and from extensive construction experience, design formulas and suggestions for procedure have been developed and are included. It was found, in part, that:

With one exception, all failures of the typical floor sections were caused by the yielding of the steel. The compression area of the section was stronger than the tension even though only ½ in of concrete topping was used. There were no shear, compression, or bond failures in the testing except in the section using the 1-in round rods. Seven-eighths inch is the maximum diameter of the reinforcing rod which the beam tile used in these tests will accommodate. Span tile, 24 in long, can be used in all cases except for heavy loading conditions or spans longer than 19 ft. Span tile, 4 in deep, is satisfactory for most loading conditions. The cost per square foot of the reinforced tile floor increases as the length of span increases. The deflection at the design load, of spans under 20 ft, is much less than the allowable of 1/360 of the span. The usual formulas for the design of reinforced concrete T-beams can be used for this type of reinforced tile floor.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE TEXAS STATION. Texas Ag. Exp. Sta. (College Station), Rpt. (1940). Under the general head of mechanical harvesting of cotton, snapping qualities of cotton bolls, spread of open cotton bolls, greenleaf studies, and plant characteristics are reported upon by H. P. Smith, D. T. Killough, D. L. Jones, and M. H. Byrom. Efficiency in distribution and placement of cottonseed and fertilizer includes machine placement of fertilizer and soil-disturbance studies, width of furrow openers, effects of press wheels, and hill dropping of cotton. Treatment of cottonseed for planting purposes, and atmospheric exposure of wire and fencing are dealt with by Smith and Byrom. Garlic drying is reported upon by Smith, Byrom, and G. E. Altstatt.

THE WIDE ADAPTABILITY OF LUMBER

enables it to do a war-time job for agriculture with speed and economy



THE NEW GOALS set for the production of food call for still greater effort on the part of agriculture. Every farm family should be given all the help and encouragement that is possible.

To provide housing for extra animals, to furnish materials for equipment that will save labor and feeds, is but one of the war-time jobs of the 4-Square Lumber Dealers. With their reduced stocks of lumber this is not an easy task.

But thanks to their versatility and the wide adaptability of lumber, its interchangeability as to species, types and grades, 4-Square Lumber Dealers are able to adapt their existing stocks to provide farmers with lumber built farm equipment—and in many cases help them effect needed repairs.

The high regard which farm structures engineers have always had for lumber as the best material for farm construction is merited by the record of lumber. It is economical. It is easy to use. And when applied in accordance with the principles of good construction, it returns its investment many fold. Weyerhaeuser will be happy to supply you with copies of its various Building Services. These are available to farmers as guides to better, more economical construction.

4-SQUARE LUMBER

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FOR ALL KINDS OF FARM MACHINERY
FOR over half a century, dependable EWC Wheels and Axles have helped keep the job rolling along. Today, when efficient speed is more important than ever, you'll find our engineering experience at your service — ready to render valuable aid in maintaining your "rolling stock" at peak performance. Write for Illustrated Bulletins describing our service on Wheels, Axles, or Mountings. (Rubber-tired wheels available on direct War Orders.)
EWC WHEELS
ELECTRIC WHEEL CO. Dept. AE Quincy, Illinois

Student Branch News

(Continued from page 394)

Our second regular meeting was held on October 26. The program was in the form of an initiation of new members and acquainting them with our constitution, by-laws, functions, and purposes of our Branch. Nineteen new members were initiated.

At our regular meeting on November 9 a quiz program was presented. This consisted of timely questions on the war, agricultural engineering, and our Branch. Prizes in the form of cigars, candy bars, and apples were awarded for correct answers. This was a most interesting program in which all present took part.

We have sixty-five agricultural engineering students, fifty of whom are members of our Branch, and we have had good attendance this quarter.

IOWA

By Kenneth W. Snyder, Scribe

AFTER A moderately active summer quarter the A.S.A.E. Student Branch at Iowa State College swung into the fall quarter with plans for a great many activities. The annual Grease Monkey's Ball, put on by Doane Conard and a committee of four, is the big item on every agricultural engineer's social calendar. Jay Porterfield is selling the dance to the student body with some new advertising ideas. Ernest Scarborough and Vincent Webster are seeing that the couples have a good time with colorful decorations and an interesting program. Jerry Kline, announces that his committee on tickets is well on the way toward making the dance a financial and social success. The dance is the first to be held in the new laboratory and will probably be the largest ever held by the Iowa Student Branch.

The second event on the calendar is the annual student-faculty mixer. It is being planned by Ray Armstrong, Ronald Schwendemann, and Quin Conard, with Dale Woolsencroft as advisor. The program planned by the students and the refreshments planned by the faculty are all arranged to give the incoming freshman a good start in agricultural engineering by introducing him to the faculty, students, and building. Stanley Swanson, president, will present Dr. J. B. Davidson who will introduce the guest speaker, Mr. H. H. Sunderlin of The Caterpillar Tractor Company.

Letter Symbols for Hydraulics and Mechanics of Solid Bodies

THE American Standards Association, 29 West 39th Street, New York, recently approved as "American Standards" Letter Symbols for Hydraulics (Z10.2-1942) and Letter Symbols for Mechanics of Solid Bodies (Z10.3-1942) copies of which standards may be obtained from the A.S.A. direct.

Some Dairy Engineering Problems

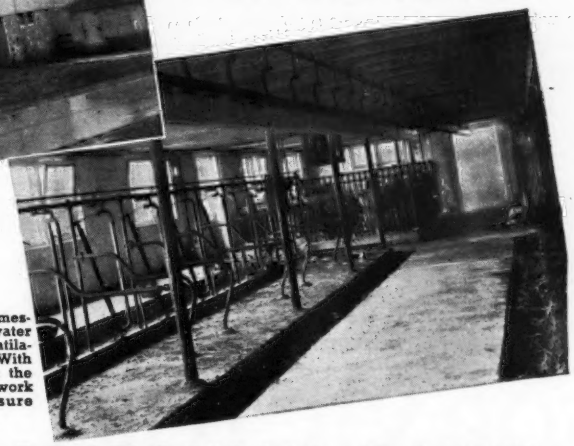
IN A report on the activities of the Committee on Dairy Engineering of the American Society of Agricultural Engineers, A. W. Farrall, chairman of the Committee, states that a survey of problems in dairy engineering, towards the solution of which agricultural engineers can be a real contribution, indicates that the following are of note: (1) Determination of efficiency of various dairy products processing equipment; (2) development of synthetic or lacquer type coatings for metals used in contact with milk products; (3) development of more efficient methods of transporting milk from farm to factory; (4) development of a practical sewage disposal system for the small dairy plant; (5) study of methods of eliminating hand labor on the dairy farm, particularly with reference to handling of sanitary problems and in disposal of barnyard wastes; (6) study of more efficient and less expensive methods of refrigeration for the farm.

Our JAMESWAY Barn is Like Having EXTRA HELP"

—say the HADLEY STOCKS of Oconomowoc, Wisconsin

Photo shows Mr. and Mrs. Stocks and one of their five children. "We're all mighty proud of our Jamesway barn," they agree. And Mr. Stocks adds, "Its labor-saving arrangement and modern equipment has a lot to do with making it possible to keep all of our cows and get top production."

Mr. Stocks wanted a barn that was handy to work in and up-to-date in every way. And he wanted it at reasonable cost. Jamesway planning and equipment filled the bill exactly." Another time I wouldn't look anywhere else. It would be Jamesway all the way for me," he says.



The barn is fitted with Jamesway stalls, stanchions, water cups, pens, box stalls, ventilation and litter carriers. With equipment like this, even the youngsters can do a man's work around the barn. That sure does help, nowadays.

PLAN *Your* JAMESWAY BARN

Thousands of good, practical farmers like Hadley Stocks, are proud of barns planned and equipped by Jamesway. And today, that efficient, labor-saving equipment is seeing them through the emergency — helping them produce more with less help.

Now is the Time to Plan a Jamesway Barn. At present, of course, new equipment is hard to get. The James Mfg. Co., like all of American industry, is producing goods needed to win this war. But the day is coming when farmers CAN have the modern barn they want. They're saving for it NOW with War Bonds . . . planning for it — with the Jamesway Man or dealer.

Jamesway TRADE MARK REG. U.S. PAT. OFF

ALL THE WAY . . .
Barn, Poultry and Hog House Equipment, Self Feeders and Ventilation.

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1943 Farm Records . .

Designed especially to organize farm business facts for easy income tax reporting . . . this practical, workable record book was made up by experienced accountants, approved by County Agents and other farm authorities.

The data from its well organized pages presents the entire farm financial story clearly, concisely, quickly — to Government agencies — banks — landlords, etc.

Free copies available for your own use or that of your clients.

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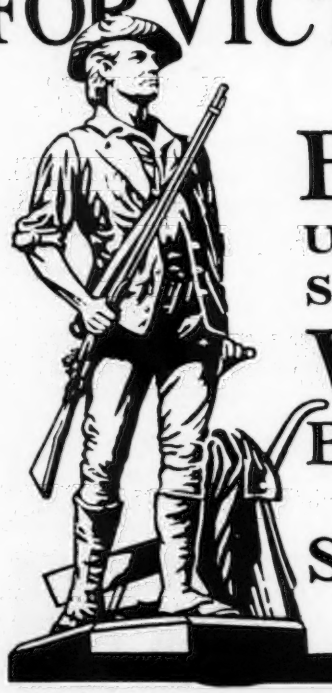
RED BRAND FENCE

FOR VICTORY



BUY UNITED STATES WAR BONDS AND STAMPS

This Space is a Contribution to Victory by AGRICULTURAL ENGINEERING

New Literature

"AMERICAN DIESEL ENGINES," by Edgar F. Goad, a licensed chief engineer. First edition. Cloth, 6x9 inches, 366 pages, 124 figures. $2.75. Harper and Brothers, New York.

This book is a full treatment of the operation, maintenance, and repair of American diesel engines. It includes both general and detailed instructions on specific engines and equipment, illustrating those most generally used in the United States at the present time. The book is written in non-technical language, for the mechanic and the inexperienced student. Three chapters explain the basic principles of diesel engines and their fuels, and these and the next five chapters provide all the material needed by the intelligent diesel operator. The remaining chapters supply the knowledge necessary for the all-around diesel mechanic, operator, and repairman. It gives him a practical picture of the types of engines he is likely to encounter from a large marine engine to automotive diesels. They also provide instruction in the operation, repair, and overhauling of these engines. The book is intended as a text for industrial, trade, and vocational classes and for training courses in the army, navy, coast guard, and the air services.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEERS wanted. ASAE headquarters understand that one of the Bureaus of the USDA is greatly in need of agricultural engineers. They can use two or three engineers each of the Junior and Assistant grades, and will probably need more at a later date. If interested, write ASAE, St. Joseph, Mich.

DESIGN ENGINEER capable of original design of farm machinery and related lines, or a man capable of developing into a real design engineer, is wanted by a well-known manufacturer of farm machinery and other equipment. Persons interested are requested to write giving full particulars regarding technical training and experience and other pertinent information. PO-140

GRADUATE ASSISTANTSHIP open in the Pacific Northwest; may be used in the field of farm structures, farm machinery, farm power, rural electrification, or land development. This fellowship provides a stipend of $450 a year on a 9-month basis, requiring about one-third the student's time for teaching and laboratory assistance in elementary engineering subjects. It may be used over a 2-year period for graduate study leading to a master of science degree in agricultural engineering. Applicants should write Hobart Beresford, head, agricultural engineering department, University of Idaho, Moscow.

AGRICULTURAL ENGINEER wanted to fill position open in northeastern university due to absence of staff member in military service. Work involves approximately half extension and half resident instruction. Major concentration in farm structures and soil and water conservation. Salary up to $3000 for qualified person. PO-137

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. S. degree in agricultural engineering from Iowa State College. Has four years' experience as engineer with the Soil Conservation Service and five years experience as state agricultural conservation engineer for the Agricultural Adjustment Administration. Experienced both in engineering and administration. Thirty-two years of age, married, and have family. References upon request. PW-348

AGRICULTURAL ENGINEER with B. S. degree in engineering and M. S. degree in agricultural engineering. Experienced in college teaching, experiment station, and extension work; also factory and construction work. Especially qualified for college agricultural engineering, manufacturing, defense, construction, or trade extension work. Age above draft. PW-346

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AGRICULTURAL ENGINEERING

DECEMBER 1942

An Engineer's View on Postwar Farm Building Construction — *Ray Crow*

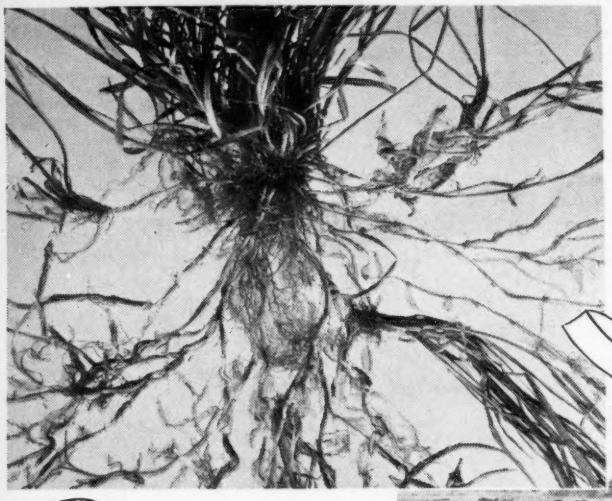
Results of Field Tests of Baling Straw Left by Combine — *A. L. Young*

A Study of the Movement of Soil During Tillage Operations — *Mech and Free*

A Method for Determining the Velocity of Runoff Water — *Cooper and Neal*

The Effect of Production Costs on Returns from Sugar Beets — *Ruden and Lambrecht*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS



Starve Out Soil Saboteurs

From Weeds to War Crops

Your farm production and your country's food program are in danger from a fifth column—weeds. Not only the ordinary weeds which are always with us, but especially the perennials like quack-grass, bindweed or creeping jenny, Canada thistle and Bermuda grass are today's soil saboteurs.

Like other saboteurs, these rootstock enemies advance underground. Ordinary cultivation will not kill them; instead, it spreads them. With farm help scarce and new farm machines even scarcer, now is no time to think of special methods and equipment. You must fight these enemies with what you have.

You can control all these rootstock weeds by using the *starvation strategy* with your present farm machines. They can no more live without leaves than you could live without lungs, though they die more slowly. When dormant from drouth or cold they can survive for months; in active growing weather they give up the ghost in a few weeks. As a rule they are weakest at the season for blooming and forming seed, and this is the time to strike.

Merely stirring the soil is worse than nothing. After the first attack you must cut off or turn under every leaf or blade by the time it is an inch high. You can do it with a disk harrow, a one-way disk plow, or a cultivator with sharp sweeps wide enough to overlap well. Your work is wasted in wet weather; the best time to do it is in hot, dry weather.

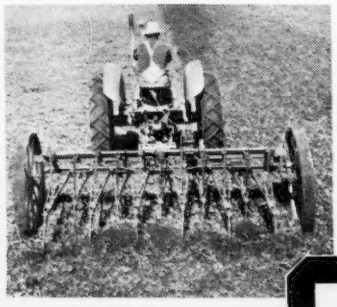
Because timing is so important, your best ally against these rootstock saboteurs is plenty of fast tractor power. Speed does a better job, too; sweeps and disks scour better and cut stems more surely when going fairly fast. Many a field given up to quack-grass and creeping jenny in the days of slow, feeble power has been conquered by tractor power and now is doing its full share in the food-for-freedom program.

★ ★ ★

If you have a Case tractor, you have both the speed and pull for modern weed-fighting. Use its power to protect the productive power of your land. Use your Case dealer's service to keep it in prime condition and lengthen its long life. As you work with your present power and machines, make plans for the new agriculture which lies ahead. Be ready, when farm machines again are available, to choose those which best will fit the new crops and the new farming methods. J. I. Case Co., Racine, Wis.

A Winning Weapon

The Case field tiller can be fitted as a duck foot cultivator with stiff beams, as shown, or with springtooth gangs. By simple change of gangs, one can be changed to the other. Wide choice of sweeps and shovels affords correct equipment for controlling various types of weeds, for conserving moisture, and for protecting soil against washing and blowing. Because the field tiller may be used to leave more or less of a stubble mulch, it should be considered for future farming wherever all-year surface cover is desirable.



★

Fight Weeds with Speed

★

CASE

SERVING AGRICULTURE *Since 1842*

As a service to agriculture, this message will appear in selected farm papers. It is one of a series urging farmers to adopt modern measures for conquering weeds and other advanced practices, using equipment they already have. J. I. Case Co., Racine, Wis.

SEGREGATED *Scrap...* is your link to VICTORY!

Scrap salvage is a vital factor in the war effort. To be fully effective a scrap program must include methods for segregating and conserving critical alloying elements so urgently needed in the construction of tanks, guns, ships and planes.

Ferrous and non-ferrous metal scrap should be collected in separate containers at the machine where they are generated. Each class of high-speed tool steel and each type of constructional alloy steel should likewise be kept separate so that the alloy content can be returned to service.

Remember, — alloy scrap which is segregated, classified and labeled according to type and composition is a vitally important commodity today—and urgently needed to augment primary supplies of Nickel, molybdenum, tungsten, etc.

The metallurgical experience of our technical staff is available to aid you in these and other phases of metal salvage.

KEEP SCRAP MOVING INTO WAR PRODUCTION!

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

EQUALS ENGINE VARNISH

IN the winter many tractors are used on belt work and in this operation, engines run hotter, causing some motor oils to form "varnish" on the pistons.

This "varnish" can make rings stick, cause pistons to drag, steal power, waste gasoline and run down batteries through hard starting.

Insulated Havoline Motor Oil is "insulated" against high engine temperatures by an exclusive Texaco process. And it is "insulated" also against cold, which causes some oils to thicken and fail to give adequate lubrication protection.

And Insulated Havoline provides another extra margin of protection. It is distilled. This means that harmful carbon-forming elements are removed. The engine tends to stay clean, giving maximum power and economy from the fuel used.

In times like these no farmer can afford to use any but the best motor oil. For good lubrication is cheaper than any machinery, and easier to buy.

Insulated Havoline and its worthy "team-mate"—Texaco Motor Oil—are available in all 48 states. And the study and research that has gone into their development has been carried out by engineers whose sole aim is to produce the best.

Any queries about Texaco lubricants will be gladly answered by one of these engineers. Telephone the nearest of more than 2300 wholesale distributing points or write to The Texas Company, 135 East 42nd Street, New York, N. Y.

*Insulated Havoline and Texaco Motor Oils and Texaco Diesel Oil cover completely the farmer's requirements for tractor, truck and automobile. For Diesel type tractors, Texaco Ursa-X** is recommended.*

THE SEARCH NEVER ENDS FOR BETTER FUELS AND LUBRICANTS IN THE TEXACO LABORATORIES

★ WARTIME STRATEGY ON THE FARM ★

LIGHT UP for better sight in the home

Proper electric lighting throughout the home means reduced eyestrain, better vision for farmers and their families.

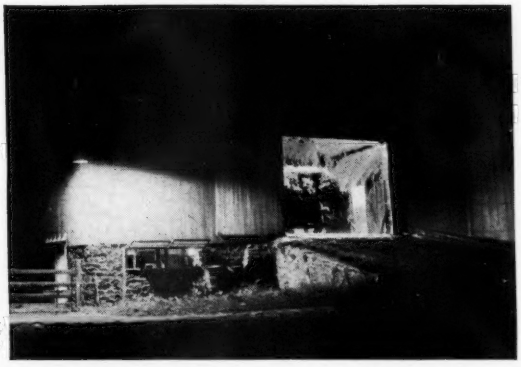
Better vision helps assure the health and vitality needed by farmers today to win the Battle of Production on the food front.

The mere use of *many lights* scattered about the home is not enough. For proper seeing, lights should be well shaded and correctly placed . . . to eliminate glare and to give the right amount of illumination.

Agricultural Engineers should know how to assist farmers in getting better lighting in their homes and on their farms.

★ *Attractive, restful lighting in the living room, bedrooms, kitchen, and bath makes life more livable after the day's work is done.*

LIGHT UP for greater safety and increased production on the farm



★ *Yard lights and interior lighting make easier your task of putting the stock in their stalls after dark.*

Properly wired, properly placed electric lights in and around farm buildings help to eliminate *two dangers* on the farm . . . the hazard of fire and the possibility of accident through stumbling over obstructions in the dark.

Good lighting also helps get more things done at night. After-dark chores are easier. Repairs to farm equipment can be made faster and better. All this aids in speeding production on the morrow.

In the hay barn, implement shed, cattle barn, and even outdoors, farmers need enough light to see clearly and safely. But they should guard against glare by using proper reflectors. Part of your job may be to help farmers get better lighting, economically and effectively.

Westinghouse

ELECTRICAL PARTNER OF AGRICULTURE

FREE LITERATURE!

WE HAVE PREPARED 12 *free* Farm Bulletins describing the wartime use of electricity on the farm. Many of these contain valuable information on farm lighting. We'll be glad to send you any of this literature if you will sign and return the coupon.

WESTINGHOUSE ELECTRIC & MFG. CO., Room 1410,
306 Fourth Avenue, Pittsburgh, Pa. (Dept. AE-122)

Please send me *free* Farm Bulletins on the application of electricity to the subjects checked below.

☐ *Beef Cattle* ☐ *Cooking, Canning, and Preservation of Food* ☐ *Clothing*
☐ *Crops* ☐ *Dairy Cattle* ☐ *Handicraft* ☐ *Home Improvement* ☐ *Poultry*
☐ *Rural Electrification* ☐ *Sheep* ☐ *Swine* ☐ *Truck Gardening*

Name.....

Address.....

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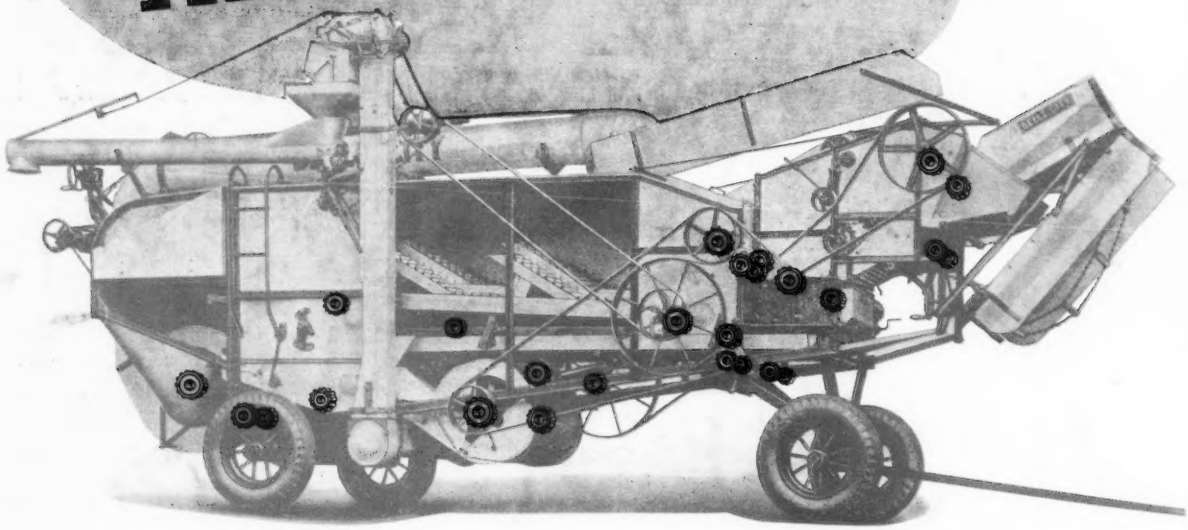

TO ASSURE VICTORY
BUY UNITED STATES WAR SAVINGS BONDS & STAMPS

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TAPERED ROLLER BEARINGS

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

Apply Timken Bearings throughout a machine and the resulting efficiency is equally valuable for war production and after Victory competition.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO